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## A Comparative Study of Web Usage and Searches at Yarmouk University and Jordan

Mohammed N. Al-Kabi, Majdi Y. Al-Shannaq and Izzat M. Alsmadi \*

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### Abstract

This study is divided into two parts. In the first part, the search trends at Yarmouk University, as a sample from Jordan Universities and Jordan public searches, were collected from Google. Queries are also extracted from Web logs of the different Internet servers at Yarmouk University. Jordanian top ranked search for queries were gathered from "Google Insights". Specific queries were eliminated from both sources for ethical reasons and inappropriate contents. Results showed that the majority of Yarmouk Internet users were interested in subjects that were related to entertainment such as pictures, multimedia and horoscopes. They were also interested in local news. A small portion (from the academic departments) is also interested in subjects related to their specialties. Comparing two sets of search for queries from Yarmouk & Jordan universities revealed no significant differences in general between them. The second part of this study compares the most frequent used Web sites at Yarmouk University collected from its web logs along with those provided by Alexa to evaluate the correlation and consistency of results between data collected from local web logs and data collected from public websites (e.g. Alexa). The study points to certain important elements regarding the Internet usage in higher educational institutes in Jordan. While it is expected that students may consume a good portion of their usage on entertainment and social networks websites, however, universities should introduce important knowledge related aspects that exist through the Internet to students. Without such organized educational effort, students may always be distracted to less knowledge relevant websites.

**Keywords:** Web log, Web log Analysis, Query trends, Google Insights, Google Zeitgeist, Alexa, usability, traffic.

### Introduction

The World Wide Web (WWW or Web for short) represents the largest sharable heterogeneous information source known today. It consists of billions of interconnected webpages via hyperlinks and authored by millions of people around the world. It dramatically has changed our search habits. The search for information before the WWW era involved asking an expert, buying/or borrowing a book or journal, going to the library, or using an information retrieval system. The WWW represents a gigantic dynamic repository of information that is stored randomly without categorization. This lead to inventing the search engines to be portals to the wide variety of information stored within this dynamic pool of information.

Many computer scientists have contributed to the improvements of search engines. The first generation of search engines involved the development of information retrieval systems. The World Wide Web has witnessed a real revolution in the world of search engines in the 1998, when Brin and Page established the Google Search Engine; which has represented a leap in the field of Web search engines [1].

A large percentage of users of the Web search engines do not know how to use the Web search engines effectively, especially, the advanced search features. As time passes, the users of search engines may improve their own Web search skills. Web searchers belong to a variety of different cultures, languages, ages, educational backgrounds, religions, professions, specialties, hobbies, gender, computer expertise,...etc, which may relatively make their information needs different as well.

Transaction logs represent an electronic record of the interaction between a user and the computer system. Analysis of such transaction logs are dated back to 1967. Web log analysis and search log analysis are sub-categories of transaction log analysis; which represents a main category [2]. In the early 1990s, simple statistics started to appear showing the number of client requests (hits) made to different Web servers. The search log analysis dated back to late 1990s and early millennium [3, 4, 5].

Servers run by Internet Service Providers (ISPs) would normally save all information related to browser's requests for different Web pages within Web log files. Examples of information that may be included in Web log files include: requested URLs, IP addresses of the visitor's computers, date and time of each browser's request, visitor's browser name and version, client operating system version, ...etc.

Web log files are a useful source of information about the usage and navigation behaviors of the Web site visitor. However, log files can also reveal the existence of both web pages and search engine queries that are sources of new visitors [6]. A search engine's transactional log is a valuable record of interaction sessions between the searchers and the Web search engine. Experts could benefit from this valuable huge data to improve the effectiveness of search engines and to enhance commercial Web campaigns (e.g. Pay-Per-Click pioneered by GoTo.com) [7].

Analyzing the huge quantities of queries submitted to search engines will help to improve ranking, personalized web search, spam detection, ... etc [8]. While analyzing the large number of queries submitted by Internet community within different establishments, or countries will reveal the culture and main interests of such communities. Google presented Google Zeitgeist (the spirit of the times) to the Internet community in 2001. Google Zeitgeist includes a number of tools that help to have insights of the Web search trends within different geographical domains (i.e. worldwide, countries, states, provinces, cities). It represents summaries of the different cultures worldwide. Google Zeitgeist presents the largest analyses process of Web queries, since it includes an analysis of millions of search queries submitted daily to Google search engine all over the world, where these queries are broken into different categories (e.g. arts & humanities, automotive, beauty & personal care, business, ... etc). Follow up to Google Zeitgeist shows that user information needs are dynamic.

Three ways that are used to analyze searchers' behaviors; the first by using installed software within searchers' computers to monitor searching interaction; the second is laboratory studies/client-side monitoring techniques with its known disadvantages (e.g. subjective-ness, small number of participants, large variance due to sampling bias). While the third way is based on searcher's behavior information found within Internet service providers' servers and search engines. This technique may overcome the shortcomings of the second way [9].

Silverstein *et al.* [10] showed that queries related to sex and pornography constitutes around 50% of the 25 most popular queries, while the vast majority of queries are categorized within sex, pornography, and entertainment [10]. Spink *et al.* [11,12] on the other hand found that percentage of Web pages that are related to sex and pornography within the WWW slightly would exceeds 1%. Therefore, there is a contradiction between the distribution of the topics of the Web user queries and the distribution of topics of the Web pages [11-12]. The same team of the last study has published another study showing the evolution of Web queries from 1997 to 2001. Consequently, their study may show the shifts in interest of users from entertainment and sex to commerce within four years [13].

We have studied and analyzed the queries submitted by the Internet users at Yarmouk University to different Web search engines. Additionally, Web usage information collected by Google Insights for Search in Jordan were collected and compared with the first collection. Different tools were used to analyze Web information collected from the two sources.

## Research background

Well known Web Search engines rely on analyzing the search behaviors of their users to develop their search services including the personalized search. The analysis of search behaviors is not an easy task, since it is based on many fields of knowledge such as: Natural Language Processing (NLP), Human Computer Interaction (HCI), user profiling and analysis, as well as many others [14].

Searching for studies related to Web log analysis in Arabic is very rare, and one of these few studies is El-Dakroury study [8]; which studied the most frequent terms used by the Internet users on one of the Arabic websites (Islamonline). He found that the most frequent terms that the users look for are: ("islamonline", "إسلام أون لاین.نت"), ("Islam", "إسلام"), ("Hadith", "حديث"), ("Islam-Almsgiving (Zakat)", "زكاة"), ("Allah", "الله"), ("Hijab(veil)", "حجاب"), ("Adhan, azaan, adhaan (Call for prayer)", "أذان"). El-Dakroury study has focused on one of the religious Web sites known in the Islamic world. The researcher has restricted his study on the site search (i.e. local search engine), and this may not be related to global Web Search [8].

Ozmutlu *et al.* [15] study was based on two representative samples drawn according to Poisson sampling. The first sample consists of 3,188 queries drawn from 1,064 users with 1.7 million Excite queries, while the second representative sample consists of 10,007 queries from 964 users with 1,257,891 queries from the Fast search engine

(<http://www.alltheweb.com>). The results of their study have revealed variations in user searching related to changes in the time of the day. The queries and the session durations are high during the morning, and then start to decrease later on the day while the number of terms per query and reformulation of queries stay the same throughout the day [15].

Jansen *et al.* [5] study was based mainly on the analysis of transaction logs containing 51,473 queries posed by 18,113 users of Excite. The study focuses on analyzing user sessions, queries, terms, and user's behaviors. These analyses revealed that the number of queries per session is generally low, and the numbers of users who reformulate their queries or view subsequent results are low. Queries' lengths are generally short, and the usage of Boolean operators and relevance feedback is low. The use of the '+' and '-' modifiers exceeds the use of Boolean operators. Most users submit one query per session, and more than 75% of users will not view more than two Web pages per session. Around 25% of the top ranked terms are sexual. One of the interesting results in the study refers to the percentage of sexual terms is less than 3% of the total number of query terms, while the frequency of using them was high [5].

Another interesting study based on a larger number of queries than Jansen *et al.* [5] study was conducted by Spink *et al.* [11]. In this study over 1.7 million Excite queries were analyzed. The results of this study mostly overlapped with the results of Jansen *et al.* [5], since both studies were based on the same data source and conducted by the same researchers [11].

Nowadays, the mobile Internet access is available in the world. Pramudiono *et al.* [16] study tries to apply association rules mining to reveal the relation between the behavior of mobile users and their locations. Access log Files of the Japanese MIS site were used to discover such relations. The generated association rules revealed that in some places, the search for restaurants has exceeded the search for other things. Some other locations focused on searches for gas stations and hotels [16].

Nadine Schmidt-Maenz and Martina Koch [17] tracked the queries that were entered at the Lycos search engine over several months. They focused on time-dependency in the usage of terms. They found out that the top 10 queries over three months in 2005 were: ("Lycos", "Link:<http://www.>", "Sex", "Hentai", "Porno", "Ebay", "Google", "Erotik", "Plexiglasgehaeuse", "Christina Aguilera"). Later on, after six months later; the top queries were: ("Lycos", "Sex", "Link:<http://www.>", "Hentai", "Porno", "Ebay", "Erotik", "Google", "Fkk", "Christina Aguilera") [17].

Most of the studies of Web query logs have focused on examining the Web query log as a closed system; where there is a concentration on the general characteristics of the queries, rather than focusing on their categories and their changes over time. This type of search is called *static analysis*. Therefore, to infer the topical trends of queries over time Beitzel *et al.* [18] developed a method called *temporal analysis*, where billions of queries from 10 million users were analyzed. This study concluded that the categorization and classification of the Web search engine's queries could improve the effectiveness and efficiency of Web search engines. Results have showed some stability of search trends despite the fluctuations in the volumes of the queries during different hours of the day [18].

Time series analysis is a statistical methods used for forecasting. Zhang *et al.* [9] study attempted to use time series analysis to develop and test a one-step prediction model for searchers' behaviors based on Dogpile search engine transactional logs for one day. Researchers have found out that 10% of Web searchers clicked on sponsored links, while almost all Web searchers clicked on organic links during the night from 22:00 to 24:00. The percentage of clicking on sponsored links may rise to more than 30% in specified periods [9].

## Methodology

This study tries to compare users of Yarmouk University with the general public information searching in Jordan. It also tries to discover whether there are any differences between the academic and the public utilization of the internet in Jordan.

The methods used in this study attempts to extract different queries from the transaction log files provided by Yarmouk University computer center and to compare them with top queries for Jordan provided by Google Insights for search. Several tools were used to extract the URLs and all other relevant information from Yarmouk University transaction log files in order to compare them with the top Web sites in Jordan according to Alexa.com and Google Insights for search.

The collected Web log files from Yarmouk University computer center covers the period from February 28<sup>th</sup>, 2010 to March 10<sup>th</sup>, 2010. The main tool that was used to perform the necessary analysis was *Sawmill*. There was also a need for a tool to extract queries from Web logs files. A tool was developed to extract queries submitted to different search engines such as Google, Yahoo, Bing, MSN, Ask, ...etc by the Internet users, and store the extracted queries on an MS Excel file. This tool is called *Web Query Extractor*. Microsoft Excel was used to perform the necessary analysis.

After quantitatively examining the extracted queries, the second part of the study aims to find whether the academic usage of the Internet within YU is consistent with Jordan's usage of the Internet.

The following steps show the general framework of this study:

Part A //Using *Web Query Extractor*:

- 1.Extracting Web queries from transaction log files
- 2.Counting the frequencies of duplicated Web queries
- 3.Sort the Web queries according to their frequencies in a descending order.
- 4.Comparing YU top Web queries with those of Jordan obtained from Google Insights.

Part B // Using *Sawmill*:

- 1.Extracting URLs from YU transaction log files.
- 2.Counting the frequencies of duplicated URLs.
- 3.Sorting the URLs according to their frequencies in a descending order.
- 4.Comparing YU top visited URLs with those of Jordan obtained from Alexa.com.

## Results and Discussion

The results of this study were based on the results obtained from the *Sawmill* analysis program and *Web Query Extractor*.

Sawmill was used to analyze the web log files, in order to get different reports about different sessions, viewed Web pages, distribution of query usage during the day hours, and days of the week, and top most frequent visited Websites. In addition, a summary report about the Web log files is generated.

The tested web log files contained data related to the Internet's usage during 11 days, from Feb 28<sup>th</sup>, 2010 to Mar 10<sup>th</sup>, 2010. The approximate total size of this sample of the Web log file was 256 GB. Table 1 shows an overview of the Sawmill results.

**Table 1:** The overview of the Sawmill results for YU Internet usage during 11 days.

|                          | <b>All days</b>      | <b>Average Per Day</b> |
|--------------------------|----------------------|------------------------|
| <b>Hits</b>              | 35,507,351           | 3,227,941              |
| <b>Page Views</b>        | 23,711,229           | 2,155,566              |
| <b>Visitors</b>          | 1,369                | 124                    |
| <b>Size</b>              | 256.32 G             | 23.30 G                |
| <b>Sessions</b>          | 21,287               | 1,935                  |
| <b>Session events</b>    | 4,058,428            | 368,948                |
| <b>Session users</b>     | 1,368                | 124                    |
| <b>Session start</b>     | 28/Feb/2010 21:59:12 | -                      |
| <b>Session end</b>       | 10/Mar/2010 09:00:06 | -                      |
| <b>Session entrances</b> | 23,454               | 2,132                  |
| <b>Session exits</b>     | 23,454               | 2.132                  |

Table 2 and Figure 1 show clearly that the use of the Internet reaches its peak on Tuesdays and Mondays (The middle of the week), while the internet usage on Fridays and Saturdays declines to the minimum. Figure 2 shows the rising hours of the Internet usage which starts from 7:00 am till 2:00 pm, where the peak hours for Internet usage lie between 7-8 am, which is unexpected.

**Table 2:** Internet usage at YU during days of the week

|                  | <b>Hits</b> | <b>Page views</b> | <b>Visitors</b> |
|------------------|-------------|-------------------|-----------------|
| <b>Sunday</b>    | 5375312     | 3467599           | 1076            |
| <b>Monday</b>    | 11332098    | 7917209           | 1218            |
| <b>Tuesday</b>   | 11875782    | 7725951           | 1227            |
| <b>Wednesday</b> | 1490341     | 779720            | 760             |
| <b>Thursday</b>  | 4573067     | 2980350           | 905             |
| <b>Friday</b>    | 365565      | 365445            | 100             |
| <b>Saturday</b>  | 495186      | 474955            | 192             |

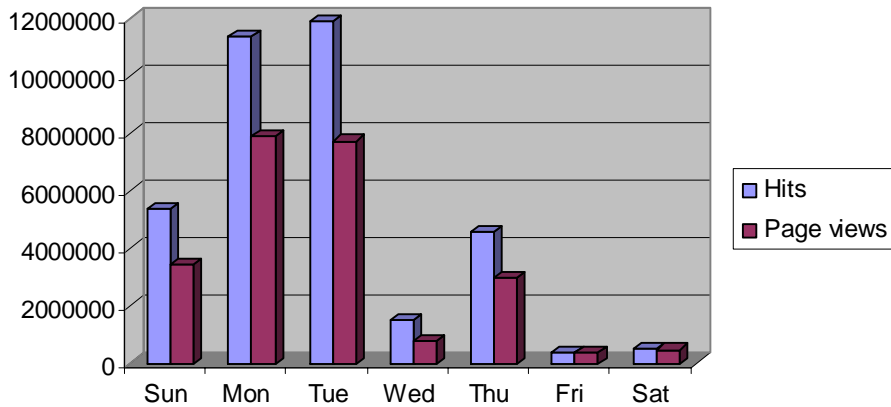


Figure 1: Distribution of the Internet usage at YU during days of the week.

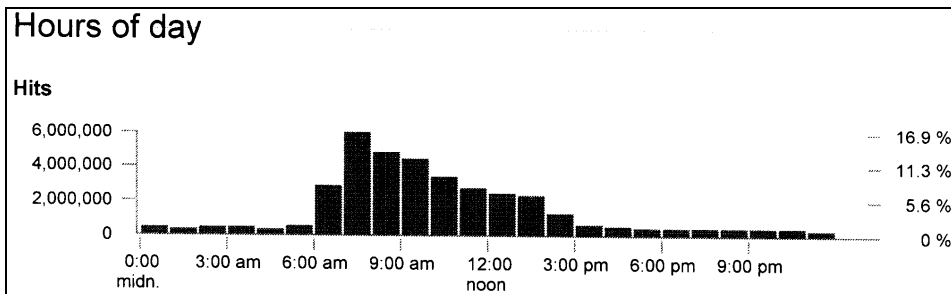


Figure 2: Distribution of the Internet usage at YU during different hours of the day.

Table 3 shows the total session events during 11 days duration of this study, besides the total number of sessions, the total number of users' session, the average sessions per user, and the average of session duration are shown.

Table 3: Sessions Overview

|                                  | All days  | Average Per Day |
|----------------------------------|-----------|-----------------|
| <b>Total session events</b>      | 4,058,428 | 368,948.00      |
| <b>Total sessions</b>            | 21,287    | 1,935.18        |
| <b>Total session users</b>       | 1,368     | 124.36          |
| <b>Average sessions per user</b> | 15.56     | -               |
| <b>Average session duration</b>  | 00:381:3  | -               |

Table 4 shows the entry pages used by most of the Internet users at Yarmouk University (YU), where this site <http://www.Google.jo> was the most favorite Web site for YU Internet users.

**Table 4:** Entry Pages

|   | Session page   | Session entrances |        |
|---|--|-------------------|--------|
| 1 | <a href="http://www.google.jo/">http://www.google.jo/</a> (default page)         | 2,648             | 11.3 % |
| 2 | <a href="http://www.yu.edu.jo/">http://www.yu.edu.jo/</a> (default page)         | 2,420             | 10.3 % |
| 3 | <a href="http://go.microsoft.com/fwlink/?">http://go.microsoft.com/fwlink/?</a>  | 2,322             | 9.9 %  |
| 4 | <a href="http://hijjawi.yu.edu.jo/">http://hijjawi.yu.edu.jo/</a> (default page) | 1,008             | 4.3 %  |
| 5 | Other Websites   | 23,458            | 64.2%  |

### Comparing Results with Alexa.com

Table 11 shows the top 20 visited Web sites during the 11 days (Feb 28, 2010 To Mar 10, 2010) duration of this study. It is clear that the most favorite Web site to the Yarmouk academic community and to the Jordanians in general is <http://www.google.jo/>

**Table 11:** Top 20 Web sites in Jordan according to Alexa.com

|    | Top Visited Web Sites<br>By Jordanians                        |    | Top Visited Web Sites<br>By Jordanians                            |
|----|---|----|---|
| 1  | <a href="http://www.google.jo">http://www.google.jo</a>       | 11 | <a href="http://www.ammonnews.com">http://www.ammonnews.com</a>   |
| 2  | <a href="http://www.facebook.com">http://www.facebook.com</a> | 12 | <a href="http://www.wikipedia.org">http://www.wikipedia.org</a>   |
| 3  | <a href="http://www.google.com">http://www.google.com</a>     | 13 | <a href="http://www.sarayanews.com">http://www.sarayanews.com</a> |
| 4  | <a href="http://www.youtube.com">http://www.youtube.com</a>   | 14 | <a href="http://www.alrai.com">http://www.alrai.com</a>           |
| 5  | <a href="http://www.yahoo.com">http://www.yahoo.com</a>       | 15 | <a href="http://www.alghad.com">http://www.alghad.com</a>         |
| 6  | <a href="http://www.live.com">http://www.live.com</a>         | 16 | <a href="http://www.traidnt.net">http://www.traidnt.net</a>       |
| 7  | <a href="http://www.maktoob.com">http://www.maktoob.com</a>   | 17 | <a href="http://www.4shared.com">http://www.4shared.com</a>       |
| 8  | <a href="http://www.kooora.com">http://www.kooora.com</a>     | 18 | <a href="http://www.conduit.com">http://www.conduit.com</a>       |
| 9  | <a href="http://www.msn.com">http://www.msn.com</a>           | 19 | <a href="http://www.khaberni.com">http://www.khaberni.com</a>     |
| 10 | <a href="http://www.blogger.com">http://www.blogger.com</a>   | 20 | <a href="http://www.aljazeera.net">http://www.aljazeera.net</a>   |

### Results by Web Query Extractor

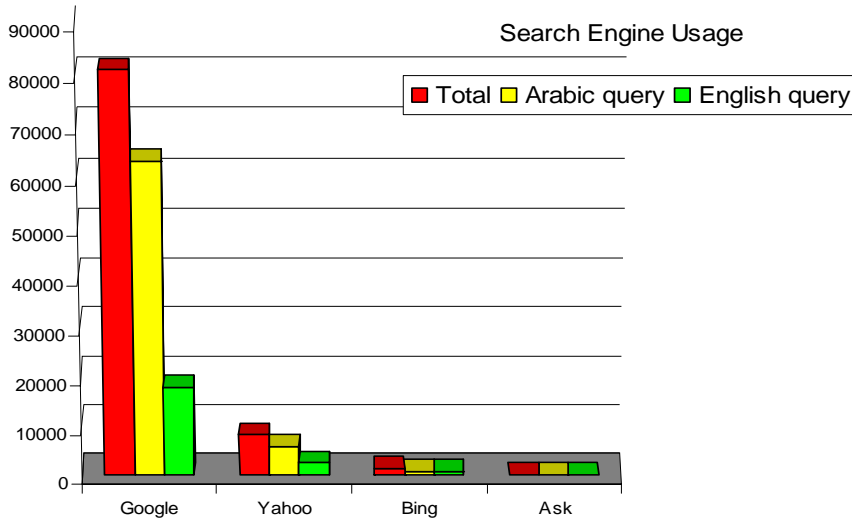
The Web Query Extractor has enabled us to extract 90,739 queries submitted by YU academic community to four search engines (Google, Yahoo, Bing and Ask), where the YU community have used mainly both English and Arabic languages to search for information to satisfy their information needs.

Table 5 and Figure 3 show the distribution of the frequencies and percentages of queries submitted to the top four search engines used by YU academic community. Google (which was the most famous search engine) was used mostly by YU academic community, and its prevalence was obvious with a 90% share relative to the others three search engines. Yahoo! Share an approximate 9%, while Bing share around 1.4%, and Ask share was 0.07%.

The percentages of using search engines within YU campus were different from the percentages showing the global shares of using each of the well-known search engines during the same period. Google has ranked first with 65.2%, followed by Yahoo with 16.9%, followed by Bing with 11.7%, followed by Ask with 3.8%, followed by AOL with 2.5% [19].

**Table (5):** Top used Search engines at Yarmouk University.

| Search Engine | English query | Arabic query | Total | Total Rate | Arabic Language Rate | English Language Rate |
|---------------|---------------|--------------|-------|------------|----------------------|-----------------------|
| Google        | 18004         | 63269        | 81273 | 89.57%     | 78%                  | 22%                   |
| Yahoo         | 2406          | 5741         | 8147  | 8.98%      | 70%                  | 30%                   |
| Bing          | 706           | 551          | 1257  | 1.39%      | 44%                  | 56%                   |
| Ask           | 30            | 32           | 62    | 0.07%      | 52%                  | 48%                   |
| <b>Total</b>  | 21146         | 69593        | 90739 |            |                      |                       |



**Figure 3:** YU academic community usage frequencies of the top 4 Search engines.

Google was ranked first as the search engine used within YU campus with a percentage of approximating 90%. The percentage of Arabic queries submitted to Google was around 78%, while the percentage of English queries submitted to Google was around 22%. The top frequent Arabic searched terms submitted to Google are shown in Appendix(1.a), while the top frequent English searched terms submitted to Google are shown in Appendix(1.b).

Yahoo! Was ranked second as the search engine used within YU, with a percentage of usage approximates to 9%. The percentage of Arabic queries submitted to Yahoo! was around 70%, while the percentage of English queries submitted to Yahoo! was around 30%. The top frequent Arabic searched terms submitted to Yahoo are shown in Appendix(2.a), and the top frequent English searched terms submitted to Yahoo are shown in Appendix(2.b).

Bing was ranked third in the usage as a search engine at YU, following Google and Yahoo! respectively, with a total of 1,257 queries. Therefore its percentage of usage within the YU academic community was (1.39%). The percentage of Arabic queries submitted to it was around 44%, while the percentage of English queries was around

56%. While top frequent Arabic searched terms submitted to Bing are shown in Appendix(3.a), and the top frequent English searched terms submitted to Bing are shown in Appendix(3.b).

Ask.com was ranked fourth with a percentage of usage approximates 0.07%. The percentage of Arabic queries submitted to Ask.com was around 52%, while the percentage of English queries submitted to Ask.com was around 48%. The top frequent terms (Arabic and English) submitted to Ask.com are shown in Appendix(4).

Checking the tables and the appendices in this study reveal that the Arabic query ("Images/pictures", "صور") was the most frequent Arabic query submitted to Google and Yahoo, while ("Fashions", "أزياء") Arabic query was the most frequent Arabic query submitted to Bing, and ("Educational leaflets", "نشرات تربية") Arabic query was the most frequent Arabic query submitted to Ask. Also, the tables and the appendices reveal that (4shared) English query was the most frequent English query submitted to Google, while (lottery) English query was the most frequent English query submitted to Yahoo, the English query (yahoo) was the most frequent English query submitted to Bing!, and (Microsoft management) English query was the most frequent English query submitted to Ask. It seems from reviewing these tables that the YU academic community used Ask search engine mainly to search for scientific and educational topics.

Table 6 shows a summary to the query tables presented in the appendices, categorized into four main topics. This table reveals clearly that the YU academic community is interested mainly in the entertainment with a percentages exceeding 50%. While the interest in academic majors was ranked second, followed by the news and communications respectively.

**Table 6:** YU Academic community search Categories.

|                       |       | Entertainment | News   | Academic<br>Majors<br>interested | Communication |
|-----------------------|-------|---------------|--------|----------------------------------|---------------|
| <b>Google/Arabic</b>  | Total | 15541         | 6492   | 3582                             | 456           |
|                       | Rate  | 59.61%        | 24.90% | 13.74%                           | 1.75%         |
| <b>Google/English</b> | Total | 3584          | 328    | 2236                             | 558           |
|                       | Rate  | 53.44%        | 4.89%  | 33.34%                           | 8.32%         |
| <b>Yahoo/Arabic</b>   | Total | 1456          | 411    | 427                              | 155           |
|                       | Rate  | 59.45%        | 16.78% | 17.44%                           | 6.33%         |
| <b>Yahoo/English</b>  | Total | 586           | 10     | 345                              | 60            |
|                       | Rate  | 58.54%        | 1.00%  | 34.47%                           | 5.99%         |
| <b>Bing/Arabic</b>    | Total | 180           | 13     | 114                              | 0             |
|                       | Rate  | 58.63%        | 4.23%  | 37.13%                           | 0.00%         |
| <b>Bing/English</b>   | Total | 172           | 0      | 124                              | 143           |
|                       | Rate  | 39.18%        | 0.00%  | 28.25%                           | 32.57%        |
| <b>Ask</b>            | Total | 44            | 3      | 15                               | 0             |
|                       | Rate  | 70.97%        | 4.84%  | 24.19%                           | 0.00%         |

Table 7 presents the low percentages of using advanced search features within the main 4 search engines.

**Table 7:** Using of Advanced Search Features, AND, OR, NOT, +, -.

|            | Google | Yahoo | Bing  | Ask   |
|------------|--------|-------|-------|-------|
| <b>And</b> | 2.07%  | 5.69% | 3.26% | 0.00% |
| <b>OR</b>  | 0.00%  | 0.00% | 0.00% | 0.00% |
| <b>Not</b> | 0.00%  | 0.00% | 0.00% | 0.00% |
| <b>+</b>   | 1.61%  | 0.08% | 0.00% | 0.00% |
| <b>-</b>   | 0.00%  | 0.00% | 0.00% | 0.00% |

Table 8 presents query average lengths within the four main search engines. It seems that the English queries submitted to Ask are longer than the English queries submitted to the other three search engines, While the Arabic queries submitted to Bing are longer than the Arabic queries submitted to the other three search engines.

**Table 8:** Average query length (in Words)

| Search Engine | Arabic      | English     |
|---------------|-------------|-------------|
| <b>Google</b> | 2.474277    | 2.994834    |
| <b>Yahoo</b>  | 2.611043    | 3.227348    |
| <b>Bing</b>   | 2.983666062 | 2.508499    |
| <b>Ask</b>    | 2.28125     | 4.133333333 |

Table 9 presents the averages of the most frequent used query lengths.

**Table 9:** Average of popular query lengths

| Search Engine | Arabic      | English     |
|---------------|-------------|-------------|
| <b>Google</b> | 1.413256108 | 1.892335222 |
| <b>Yahoo</b>  | 1.674561045 | 3.076923077 |
| <b>Bing</b>   | 2.749185668 | 2.184510251 |
| <b>Ask</b>    | 2.28125     | 4.133333333 |

All SE average term = 2.61

### Comparing the Results with Google Insights For Search

By tracking the Google Insights for Search during the time period from 29/Mar/2010 till 28/Apr/2010 for the following Arab countries (Tunisia, Algeria, Sudan, Libya and Jordan)\*. We summarized the top 10 searches in these countries as shown in Table (10). The query ("Games", "العاب") ranked was second in Jordan (by Google Insights for Search), while it was ranked fourth within the Arabic queries submitted by YU community to Google. The query ("Images/pictures", "صور"), ranked fourth in

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\* We chose these countries by agreement with the other students, who will study the web log for other universities and comparing their results with Google Zeitgeist for other countries.

Jordan (by Google Insights for Search, table (10)), while it is ranked first within the Arabic queries submitted by YU community to Google. The English query “Facebook” was ranked third within Google Insights for Search and within the English queries submitted to Google by YU community. This comparison is restricted to Jordan, since the university under study is in Jordan.

**Table (10):** The top 10 searches in (Tunisia, Algeria, Sudan, Libya and Jordan) from Google Insights web page.

| Rank | Countries   |             |                 |                      |          |
|------|-------------|-------------|-----------------|----------------------|----------|
|      | Tunisia     | Algeria     | Sudan           | Libya                | Jordan   |
| 1    | facebook    | algerie     | facebook        | ليبيا                | الاردن   |
| 2    | tunisie     | facebook    | السودان (Sudan) | صور                  | العاب    |
| 3    | telecharger | telecharger | download        | yahoo                | facebook |
| 4    | jeux        | youtube     | youtube         | الشعبية العامة للجنة | صور      |
| 5    | google      | jeux        | yahoo           | facebook             | download |
| 6    | yahoo       | yahoo       | اغاني           | العاب                | اغاني    |
| 7    | video       | الشروق      | hotmail         | اغاني                | سرايا    |
| 8    | traduction  | العاب       | العاب           | اليوم ليبيا          | youtube  |
| 9    | msn         | video       | google          | google               | الراي    |
| 10   | mail        | google      | الجزيرة         | العربية              | yahoo    |

### Study Implications

Websites of universities are important portals for current, past and future students, instructors and employees. Having a website with correct and current information is a must for a reputable university. Students register for courses, submit assignments and upload several other types of information. On the other side, the university de facto information outlet is its website that through which it communicates with its current, past and future: students, employees, and instructors. Those unique requirements require university websites to be usually large in terms of size and other structural metrics. On the other hand, there is a need to keep the website popularity and visibility high particularly for future students and employees (or any external viewers).

Studying the usage of Internet by the students and university employees can help the university understand Internet usage behavior of its society. Based on this knowledge they can educate their local society and help them in improve their knowledge and educational information through the Internet.

### Conclusion

In this research, we have tried to analyze Yarmouk University Internet users' behavior on one side and Jordan as a country on the other side. The collected data are collected from four main sources: Yarmouk University web log files, Google Insights,

Google Zeitgeist, and Alexa. One of the interesting results within this research that Internet heavy usage is maximal during the first 3 days of the week relative to the remaining days. Results indicated also that the majority of Internet users in Jordan are not utilizing the large amount of valuable information available in the Internet. The study focused on universities, as the people in those universities working in academic centers are expected to benefit more from the large amounts of information available through the Internet and, at the same time, they appreciate the need for Internet availability through the university campus. Despite the fact that the results showed some more focus on the “good” usage of the Internet from those universities, however, expectations regarding Internet usage were higher than actual information gathered.

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## **دراسة مقارنة لإستخدامات الشبكة العنكبوتية وعمليات البحث ضمن جامعة اليرموك والأردن**

محمد الكعبي، مجدي الشناق وعزت الصمادي

### **ملخص**

تهدف هذه الدراسة إلى التعرف على اتجاهات البحث الخاصة بمستخدمي شبكة الإنترنت في جامعة اليرموك كعينة أكاديمية تمثل إحدى الجامعات الأردنية، ومقارنة نتائج البحث الخاصة بالجامعة المذكورة مع النتائج التي تقدمها شركة جوجل (Google) على مدار الساعة من خلال صفحتهم رؤى جوجل للبحث (Google Insights for search) والخاصة بالمملكة الأردنية الهاشمية، للتعرف على أوجه التشابه والاختلاف ما بين البحث على المستوى الأكاديمي والبحث على مستوى الوطني. وقد توصلت الدراسة إلى أن هناك تطابقاً ما بين البحث على المستوى الأكاديمي مع البحث على المستوى الوطني، إذ ينصب الاهتمام بالدرجة الأولى في البحث على المواضيع المتعلقة بالترفيه على المستويين الجامعي والوطني، ويأتي الاهتمام بالاختصاص بالدرجة الثانية على المستوى الأكاديمي.

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## Appendix

**APP (1.a):** The most frequent Arabic terms submitted to Google by the YU community.

| #  | The term           | Freq. | #  | The term                | Freq. | #  | The term           | Freq. |
|----|--------------------|-------|----|-------------------------|-------|----|--------------------|-------|
| 1  | صور                | 2808  | 35 | غرائب<br>وعجائب         | 171   | 68 | ثيمات              | 69    |
| 2  | ابراج              | 1593  | 36 | منتدى طلاب<br>اليرموك   | 171   | 69 | قصص واقعية         | 69    |
| 3  | جامعة اليرموك      | 1532  | 37 | الالعاب                 | 158   | 70 | اخبار الرياضة      | 67    |
| 4  | الرأى              | 1350  | 38 | شعر                     | 141   | 71 | الدوري<br>الاسباني | 67    |
| 5  | العاب              | 1346  | 39 | كلمات اغاني             | 139   | 72 | كلام حب            | 67    |
| 6  | الدستور            | 1096  | 40 | ديوان الخدمة<br>المدنية | 135   | 73 | الشرفات            | 66    |
| 7  | مسجات              | 931   | 41 | مكتوب                   | 134   | 74 | الغاز              | 66    |
| 8  | نتائج التوجيهي     | 901   | 42 | اسئلة                   | 125   | 75 | كاريكاتور          | 66    |
| 9  | فرفش               | 605   | 43 | تحليل<br>الشخصية        | 120   | 76 | افلام              | 64    |
| 10 | السرايا            | 587   | 44 | دليل الهاتف             | 115   | 77 | اجمل الصور         | 63    |
| 11 | الطقس في<br>الاردن | 580   | 45 | الحقيقة                 | 114   | 78 | حرب القبايل        | 63    |
| 12 | الجزيرة الرياضية   | 487   | 46 | شات                     | 113   | 79 | مكياج              | 62    |
| 13 | السوسنة            | 479   | 47 | ترجمة                   | 112   | 80 | اخبار الفنانين     | 60    |
| 14 | مسلسل عاصي         | 476   | 48 | مترجم                   | 106   | 81 | برامج كمبيوتر      | 60    |

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| #  | The term           | Freq. | #  | The term               | Freq. | #   | The term                 | Freq. |
|----|--------------------|-------|----|------------------------|-------|-----|--------------------------|-------|
| 15 | نكت                | 476   | 49 | دردشة                  | 104   | 82  | تردد القنوات             | 60    |
| 16 | تفسير احلام        | 464   | 50 | رحيم                   | 102   | 83  | لعبة ماريو               | 60    |
| 17 | الغد               | 453   | 51 | خبرني                  | 99    | 84  | الاخبار الاردنية         | 59    |
| 18 | اغاني              | 404   | 52 | لعبة من سيربح البونبون | 98    | 85  | اخر التساريح للشعر       | 58    |
| 19 | تحميل              | 397   | 53 | هيفاء وهبي             | 97    | 86  | وزارة التربية الاماراتية | 56    |
| 20 | كوورة              | 384   | 54 | طرائف                  | 93    | 87  | اعرف شخصيتك              | 55    |
| 21 | عمون               | 326   | 55 | الحب                   | 92    | 88  | طريقة عمل كيكة الاناناس  | 55    |
| 22 | مسلسل جواهر التركي | 326   | 56 | دراسات تربوية          | 91    | 89  | اخبار اليوم              | 53    |
| 23 | امنية              | 322   | 57 | يو تيوب                | 89    | 90  | الاردن                   | 53    |
| 24 | حضك اليوم          | 281   | 58 | اشعار                  | 85    | 91  | فلسطين                   | 52    |
| 25 | ريال مدريد         | 269   | 59 | فيس بوك                | 85    | 92  | العربية                  | 51    |
| 26 | معاني اسماء        | 247   | 60 | كيف تجعل شخص يحبك      | 83    | 93  | مشاريع تخرج              | 51    |
| 27 | وظائف              | 222   | 61 | رسائل حب ورومانسيه     | 80    | 94  | المدرّب                  | 50    |
| 28 | فساتين             | 217   | 62 | اجمل المسجات           | 79    | 95  | نزار قباني               | 49    |
| 29 | ستار اكاديمي       | 196   | 63 | اناشيد                 | 79    | 96  | اخبار الاردن             | 48    |
| 30 | ازياء              | 182   | 64 | نانسي                  | 79    | 97  | الغابة العربية           | 48    |
| 31 | مسلسل وادي الذئاب  | 182   | 65 | كيف تعرف شخصيتك        | 77    | 98  | بكرا                     | 48    |
| 32 | من سيربح الملايين  | 182   | 66 | خواطر                  | 76    | 99  | بيت راس                  | 48    |
| 33 | برشتونه            | 175   | 67 | اليسا                  | 70    | 100 | ابحث                     | 47    |
| 34 | فيديو              | 173   |    |                        |       |     |                          |       |

**APP (1.b):** The most frequent English terms submitted to Google by the YU community.

| #  | The term                         | Freq. | #  | The term  | Freq. | #  | The term   | Freq. |
|----|----------------------------------|-------|----|---|-------|----|--|-------|
| 1  | 4shared                          | 364   | 35 | games   | 61    | 68 | wwe  | 33    |
| 2  | yahoo                            | 329   | 36 | tax evasion   | 61    | 69 | google translate   | 31    |
| 3  | facebook                         | 304   | 37 | umniah  | 54    | 70 | sir philip sidney<br>astrophel and<br>stella                             | 31    |
| 4  | freegate                         | 233   | 38 | bluetooth   | 52    | 71 | unblock<br>facebook  | 31    |
| 5  | download                         | 224   | 39 | requirement<br>system   | 51    | 72 | dictionary   | 30    |
| 6  | cn blue                          | 222   | 40 | manual solution   | 50    | 73 | Implement<br>AND, OR, INV,<br>and XOR gates<br>using NAND<br>gates ONLY. | 30    |
| 7  | free download                    | 179   | 41 | D.N.A   | 49    | 74 | probability<br>random  | 30    |
| 8  | myege                            | 170   | 42 | clipart   | 48    | 75 | types of<br>processors   | 30    |
| 9  | proxy                            | 132   | 43 | learn matlab<br>step by step                                  | 48    | 76 | ecg circuit  | 28    |
| 10 | art sport                        | 131   | 44 | cartoon   | 46    | 77 | sequence of<br>3phase fault  | 28    |
| 11 | kooora                           | 128   | 45 | essay about<br>election                                       | 44    | 78 | fatafeat   | 28    |
| 12 | circuit maker<br>and speedometer | 121   | 46 | Microelectronic<br>s Circuit                                  | 44    | 79 | chat   | 27    |
| 13 | mbc                              | 121   | 47 | use case  | 44    | 80 | inventory of<br>threats  | 27    |
| 14 | google earth                     | 111   | 48 | adobe<br>photoshop  | 43    | 81 | othello  | 27    |
| 15 | racism                           | 99    | 49 | wireless  | 43    | 82 | project for<br>computer<br>engineering                                   | 27    |
| 16 | william<br>shakespeare           | 98    | 50 | requirements<br>for developing a<br>inference<br>engine in c# | 42    | 83 | X10 protocol   | 27    |
| 17 | hotmail                          | 97    | 51 | DATA SHEET  | 41    | 84 | it.yu.edu.jo   | 27    |
| 18 | freebrowes                       | 95    | 52 | gta   | 41    | 85 | electronic<br>project for<br>building<br>Speedometer                     | 26    |
| 19 | farfesh                          | 92    | 53 | sex   | 41    | 86 | icanaccess   | 26    |

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| #  | The term                               | Freq. | #  | The term               | Freq. | #   | The term                      | Freq. |
|----|--|-------|----|------------------------|-------|-----|-------------------------------|-------|
| 20 | youtub                                 | 89    | 54 | panet                  | 40    | 87  | password dictionary search    | 26    |
| 21 | hih2                                   | 88    | 55 | real madrid            | 40    | 88  | vtunhel                       | 26    |
| 22 | nokia                                  | 88    | 56 | Drawing 2 chart excel  | 39    | 89  | articles                      | 25    |
| 23 | c                                      | 87    | 57 | haifa                  | 39    | 90  | Btunnel                       | 25    |
| 24 | yu                                     | 86    | 58 | the lamb analysis      | 39    | 91  | c++                           | 25    |
| 25 | orange                                 | 78    | 59 | TVTA                   | 38    | 92  | educatioal psychology elliott | 25    |
| 26 | matlab                                 | 75    | 60 | aforge.net             | 37    | 93  | firefox                       | 25    |
| 27 | the lottery                            | 75    | 61 | yarmouk University     | 37    | 94  | java                          | 25    |
| 28 | 2 unblocksites                         | 70    | 62 | FaceFilter Studio 2.0v | 35    | 95  | php                           | 25    |
| 29 | metal detector                         | 70    | 63 | saraya                 | 35    | 96  | convert pdf to word           | 24    |
| 30 | ninja proxy                            | 70    | 64 | v-ray                  | 35    | 97  | free proxy                    | 24    |
| 31 | picture                                | 70    | 65 | windows 7              | 35    | 98  | hd                            | 24    |
| 32 | aljazeera                              | 69    | 66 | mp3                    | 34    | 99  | network                       | 24    |
| 33 | speedometer                            | 67    | 67 | hp                     | 33    | 100 | prison break                  | 24    |
| 34 | speed measurement of objects on a path | 64    |    |                        |       |     |                               |       |

APP (2.a): The most frequent Arabic terms submitted to Yahoo by the YU community.

| # | The term          | Freq. | #  | The term      | Freq. | #  | The term                   | Freq. |
|---|-------------------|-------|----|---------------|-------|----|----------------------------|-------|
| 1 | صور               | 411   | 18 | وظائف شاغرة   | 39    | 35 | خلطات الدكتور مبارك الاشقر | 23    |
| 2 | جامعة اليرموك     | 166   | 19 | الدستور       | 38    | 36 | طقس الاردن                 | 19    |
| 3 | مسجات             | 132   | 20 | حالة الطقس    | 38    | 37 | نظام الخدمه المدنيه        | 18    |
| 4 | مسلسل عاصي التركي | 93    | 21 | كووره         | 37    | 38 | غرف نوم                    | 17    |
| 5 | فرقش              | 89    | 22 | سرايا         | 37    | 39 | التكامل                    | 16    |
| 6 | الغد              | 88    | 23 | ستار اكاديمي  | 35    | 40 | انجازات بنك الفقراء        | 16    |
| 7 | الابراج           | 79    | 24 | معاني الاسماء | 31    | 41 | سيارات                     | 16    |
| 8 | الراي             | 79    | 25 | العاب         | 31    | 42 | كراميش                     | 16    |

| #  | The term       | Freq. | #  | The term                         | Freq. | #  | The term                  | Freq. |
|----|----------------|-------|----|----------------------------------|-------|----|---------------------------|-------|
| 9  | نكت            | 68    | 26 | فضائل سور القران                 | 30    | 43 | منتديات طلاب اليرموك      | 16    |
| 10 | مكتوب          | 67    | 27 | مجموعة ورقات                     | 30    | 44 | رسائل الحب والغرام والشوق | 15    |
| 11 | نتائج التوجيهي | 63    | 28 | شات                              | 29    | 45 | شهم ارشيد                 | 15    |
| 12 | حظك اليوم      | 62    | 29 | مسلسل جواهر التركي               | 29    | 46 | موقع اورنج                | 15    |
| 13 | امنية          | 59    | 30 | زاد الاردن                       | 28    | 47 | اليسا                     | 14    |
| 14 | تفسير الاحلام  | 59    | 31 | هيفا وهي                         | 26    | 48 | حلويات                    | 14    |
| 15 | فساتين         | 57    | 32 | انحرافات القوام واسبابها         | 25    | 49 | دليل الهاتف               | 14    |
| 16 | عمون           | 47    | 33 | تحميل                            | 25    | 50 | وزارة التربية والتعليم    | 14    |
| 17 | قصي خولي       | 40    | 34 | تاريخ العلاقات الجزائرية المصرية | 24    |    |                           |       |

**APP (2.b):** The most frequent English terms submitted to Yahoo by the YU community.

| #  | The term                      | Freq. | #  | The term                            | Freq. | #  | The term                                 | Freq. |
|----|-------------------------------|-------|----|-------------------------------------|-------|----|--|-------|
| 1  | the lottery                   | 75    | 18 | freigate                            | 19    | 35 | game                                     | 23    |
| 2  | btunnd                        | 64    | 19 | the best way to take a photographic | 19    | 36 | manual system' forex                     | 19    |
| 3  | 4shared                       | 57    | 20 | WWW.HUDIFA H_,COM                   | 19    | 37 | microsoft project manger                 | 18    |
| 4  | nokia                         | 52    | 21 | hotmail                             | 18    | 38 | thesis statment in "The Lottery"         | 17    |
| 5  | metal detector                | 42    | 22 | freebrowes                          | 17    | 39 | Ultrasonic Range Finder                  | 16    |
| 6  | Microelectronics Circuit      | 31    | 23 | yahoo                               | 17    | 40 | age of empires 2 free download full game | 16    |
| 7  | myegy                         | 30    | 24 | the disembodied soul                | 16    | 41 | c  | 16    |
| 8  | facebook                      | 26    | 25 | tax evasion in jordan               | 15    | 42 | gurren lagann                            | 16    |
| 9  | poossessing the secret of joy | 26    | 26 | esraakamaisheh@yahoo.com            | 14    | 43 | just University                          | 16    |
| 10 | educatioal psychology elliott | 25    | 27 | cars                                | 13    | 44 | koora                                    | 15    |
| 11 | google                        | 25    | 28 | clean usb flash                     | 13    | 45 | mbc                                      | 15    |

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| #  | The term                                     | Freq. | #  | The term                        | Freq. | #  | The term                            | Freq. |
|----|--|-------|----|---------------------------------|-------|----|-------------------------------------|-------|
| 12 | circuit maker download and speedometer       | 24    | 29 | proxy                           | 13    | 46 | N-grams and Spam                    | 15    |
| 13 | download                                     | 23    | 30 | adaptation of insect in desert  | 12    | 47 | pdf reader free download for iphone | 14    |
| 14 | www.yu.edu.jo                                | 22    | 31 | an orient in dubliners          | 12    | 48 | smackdown                           | 14    |
| 15 | how to make comic edditng with photoshop     | 21    | 32 | Free Website Design             | 12    | 49 | state of trance                     | 14    |
| 16 | sap  | 21    | 33 | frequency of contraction muscle | 12    | 50 | traffic control asm chart           | 14    |
| 17 | Develop and test a method for spam filtering | 20    | 34 | forex manual system             | 11    |    |                                     |       |

APP (3.a): The most frequent Arabic terms submitted to Bing by the YU community.

| #  | The term                       | Freq. | #  | The term                              | Freq. | #  | The term                   | Freq. |
|----|--------------------------------|-------|----|---------------------------------------|-------|----|----------------------------|-------|
| 1  | ازياء                          | 35    | 11 | جيف هاردي                             | 9     | 21 | سوريا و صندوق النقد الدولي | 7     |
| 2  | أبو ظبي الوثائقية              | 24    | 12 | حدائق الاردن                          | 9     | 22 | صور المسكوكات الاسلامية    | 7     |
| 3  | الابراج                        | 16    | 13 | جورج وسوف                             | 9     | 23 | مباراة الاردن وسنغافورة    | 7     |
| 4  | تامر حسني                      | 16    | 14 | مهرجان ادونيا                         | 9     | 24 | البحث العلمي               | 6     |
| 5  | مسلسل وادي الذئاب الجزء الثالث | 14    | 15 | الخصائص السلوكيه لحالات صعوبات التعلم | 8     | 25 | التوافق الاجتماعي          | 6     |
| 6  | جامعة اليرموك                  | 13    | 16 | ترين                                  | 8     | 26 | القيادة التربوية           | 6     |
| 7  | مسلسل جواهر التركي             | 13    | 17 | حب الشباب                             | 8     | 27 | اناشيد                     | 6     |
| 8  | نتائج اتوجيهي                  | 13    | 18 | اسحق نيوتن                            | 7     | 28 | نتائج القبول الموحد        | 6     |
| 9  | مسجات حلوة                     | 11    | 19 | التخطيط الاستراتيجي                   | 7     | 29 | الجدول الدراسي -           | 5     |
| 10 | ستار اكايمي                    | 10    | 20 | الدستور                               | 7     | 30 | د أمل نصير                 | 5     |

**APP (3.b):** The most frequent English terms submitted to Bing by the YU community.

| #  | The term              | Freq. | #  | The term                           | Freq. | #  | The term                              | Freq. |
|----|-----------------------|-------|----|------------------------------------|-------|----|---------------------------------------|-------|
| 1  | yahoo                 | 72    | 11 | free download fifa 2010 for iphone | 12    | 21 | car picture 2010                      | 7     |
| 2  | googel                | 48    | 12 | goal.com                           | 12    | 22 | color paints                          | 7     |
| 3  | facebook              | 37    | 13 | méthodologie                       | 12    | 23 | www.unblouke.com                      | 7     |
| 4  | www.yu.edu.jo         | 26    | 14 | <a href="#">jordan</a>             | 10    | 24 | fox cars                              | 6     |
| 5  | asain journal         | 21    | 15 | <a href="#">beutifull women</a>    | 10    | 25 | poeples magazene                      | 6     |
| 6  | SUMMARY OF PASSING    | 20    | 16 | <a href="#">facelty.yu.edu.jo</a>  | 9     | 26 | the most beutifull eyes in the woirdl | 6     |
| 7  | freebrowse.net        | 17    | 17 | it.yu.edu.jo                       | 8     | 27 | www.sis.yu.edu.jo                     | 6     |
| 8  | hotmail               | 15    | 18 | umniah                             | 8     | 28 | add_ons on facebook                   | 5     |
| 9  | www.bani-hasan.com/vb | 14    | 19 | www.cpf.gov.jo                     | 8     | 29 | photo by cs3                          | 5     |
| 10 | proxy                 | 13    | 20 | bungee jumping videos              | 7     | 30 | www.wikipèdia.fr                      | 5     |

**APP (4):** The most frequent terms (Arabic and English) submitted to Ask by the YU community.

| # | The term                   | Freq. | #  | The term                            | Freq. |
|---|----------------------------|-------|----|-------------------------------------|-------|
| 1 | what is microsoft mangment | 28    | 6  | امجد قورشه                          | 3     |
| 2 | نشرات تربوية               | 7     | 7  | أسماء مصانع تحتاج مهندسين كيميائيين | 3     |
| 3 | اغاني اليسا                | 6     | 8  | صور للتصاميم                        | 3     |
| 4 | مسجات روعة وحلوة           | 5     | 9  | فزاع                                | 2     |
| 5 | الاردن                     | 3     | 10 | empathize with non english speakres | 2     |

# An Approach for Representing the Mined Knowledge to Support Decision Making

Qasem A. Al-Radaideh\*

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## Abstract

Recently, there has been a growing interest in the data mining area, where the objective is the discovery of knowledge that is correct, comprehensible, easily interpreted, and can be understood and used by users. In building decision support systems, one of the biggest problems is the issue of gaining data and knowledge, and their mutual representation. This paper addresses the issue by facilitating the automatic construction of a decision support system by utilizing data mining techniques. Rough Set Theory is one of the well known techniques used to extract knowledge. In this research a system that extracts rules based on rough set theory is built where the extracted rough based classification rules are transformed into a program that can be used as a tool to predict the decision class of new objects with unknown class for the purposes of decision making. The generated program is equipped with all the necessary constructs and functions that facilitate the decision making process. The proposed approach extends the main steps of Knowledge Discovery in Database (KDD) to include a new step that involves the representation of the extracted knowledge to ease the process of decision support.

**Keywords:** Data Mining, Rough Set Theory, Classification Rules, Classifier, Decision Making.

## Introduction

Raw data is rarely of direct benefit. Its true value is on the ability to extract information useful for decision support or exploration. In most domains, data analysis was governing a manual process. Recently, there has been a growing interest in the data mining area, where the objective is the discovery of knowledge that is not only correct, but also comprehensible and even usable by the user [1, 2]. The discovered knowledge cannot be easily interpreted and understood; in this case the discovered knowledge needs to be transformed into a form that can be understood by human users [3]. Therefore, the user can quickly understand the results of the system and combine them with the knowledge of the problem in order to support a decision making process.

The grand challenge of knowledge discovery in databases is to automatically process large quantities of raw data, identify the most significant and meaningful patterns and present this knowledge in an appropriate form for achieving the user's goal

which includes decision support or exploration [1]. Commonly, the discovered knowledge cannot be easily interpreted and understood by human users. In this case, to get benefit from the discovered knowledge, the knowledge needs to be transformed into a form that can be understood and used by human users where the user can easily understand the results of the knowledge discovery process and combine them with the knowledge of the problem in order to support a decision making process. The question arises here, how could a KDD system represents the extracted knowledge in such a way that is convenient and usable by the end user?

Decision support systems are aimed at helping decision makers solve problems and make decisions automatically based on a predefined knowledge based. The main source of knowledge for decision systems is human knowledge formalized in a format requested by a selected decision system tool. Recently data mining is used to handle this issue by automatically providing the decision systems with the required knowledge by extracting the knowledge from the available data using some intelligent techniques [4].

According to Han and Kember [1], there are several tasks in data mining and the most common in literature is classification, which is a form of data analysis that can be used to extract models describing important data classes. Using the extracted model, the classification task concentrates on predicting the value of the decision class for an object among a predefined set of class values given the values of some given attributes for the object.

In general, data classification is a two-step process. In the first step, which is called the learning step, a model that describes a predetermined set of classes or concepts, will be built by analyzing a set of training database objects. Each object is assumed to belong to a predefined class. In the second step, the model is tested using a different data set. The classification accuracy is estimated using one of several proposed techniques. If the accuracy of the model is considered acceptable, the model can be used to classify future data objects for which the class label is not known. The model will act as a classifier in the decision making process

Rough set theory [5] was developed in Poland in the early 1980s as a mathematical tool for knowledge discovery and data analysis, and concerns itself with the classificatory analysis of imprecise, uncertain or incomplete expressed in terms of data acquired from experience. The notion of classification is central to the approach; the ability to distinguish between objects, and consequently reason about partitions of the universe.

The research presented in this paper proposes to transform all the extracted knowledge into software components and programs. In this research a system that extracts rules based on rough set theory is built. To address the comprehensibility and the usability issues of the output of the rough set based classification system, a model that implements the translation of the extracted rules into software components is implemented and embedded in the system. The generated software is ready to run and to be used by the decision maker to help in taking actions and decision regarding any new case which was not used in the training and testing phases of the data mining process.

The constructed program will act as a decision support system and the Rough set theory is used as a knowledge acquisition tool. By automatic software construction relying on experimental data, great programming efforts should be saved. This leads to a faster decision making process.

## **Related Work**

To provide the extracted knowledge to the end user, the literature provides three main approaches to deal with this issue. Most available methods present the extracted knowledge in plain format as a set of rules or set of statements that describe the extracted knowledge. Another attractive and available solution for this issue is to provide visualization to represent the extracted knowledge [6]. The main proposed approaches are presented in the following points.

Gajzler in [7] presented in his article the various possibilities of using data mining techniques in building decision support systems. He states that one of the biggest problems in this area is the issue of gaining data and knowledge, their mutual representation and reciprocal usage. Gajzler proposed to obtain a ready model containing knowledge, e.g., a trained artificial neural network. This approach was proposed to be used instead of the classical and long-term knowledge acquisition methods.

### ***Reports and Visualization***

In the first approach to represent the output of the knowledge discovery process, the output is presented to end user in one or more of the following forms: printed reports which may include set of rule, mathematical formulas with some explanations, and visualization which may include trees, charts, and figures [6].

Most of these forms for representing the extracted knowledge need experts (such as domain expert and data mining experts) to interpret and get benefit out of them. Moreover, in the case of large datasets in real world applications, the generated model will be very huge and it is a difficult task to visualize the model and if it is presented in plain format, it will be very hard if not impossible for the end user to trace and use the extracted knowledge. The decision maker, who is a data mining end user, needs to get use of the extracted knowledge in a short processing time. The decision maker needs to use the model to predict decision values of the new available objects to help in the decision making process.

### ***Rule Discovery as Knowledge Acquisition***

Knowledge acquisition is referred to as a bottleneck problem in developing expert systems [8], which has not fully been solved and is expected to be solved by induction of rules from databases. For this purpose, researchers develop expert systems by using the acquired knowledge resulted out of a knowledge discovery process [4, 7-9].

In this second approach, what if the data mining algorithm being used gives acceptable results during the testing and experiments phases and the end user decided to use the output of the KDD process to support the decision making process? In this case the end user, who is the original owner of the data, will ask some professional programmers to build a system (probably expert system) that embeds or uses the

extracted knowledge as knowledge base. To build such a system, some programming efforts are required.

### ***Transforming Rules into Plain Source Code***

In the third approach, and to ease the second approach, the extracted knowledge is represented in a source code format ready to be embedded in decision support software. This idea of exporting the extracting rules into code of programming languages has attracted some researchers. The research by [10] proposed an approach to develop decision support systems where Rough Set theory is used in knowledge acquisition and processing phases. According to the authors, a system called *DataLogic* system is used to transfer the obtained knowledge from the dataset into the form of rule knowledge base. The rules are translated into Prolog rules form where Prolog has been used as a knowledge representation for the extracted rules. Nevertheless, the prolog code needs to be embedded in a procedural language program to be used.

Krishnaswamy and Zaslavsky in [11] proposed a model for the automated translation of the decision rules extracted from database into active database constructs. The constructs are presented as PL/SQL triggers and stored procedures for Oracle database where in a next step a system needs to be built on top of these triggers and constructs.

The ROSETTA toolkit [12] is not intended as a decision support system in the sense of being for example a tool for patient-specific consultation. Rather, the toolkit produces output that can be embedded in programs specially tailored for decision support of that kind. The ROSETTA toolkit has the option of exporting the extracted rules into Matlab format, C++ code, Prolog clauses, or plain format. The exported rules can be embedded in programs specially tailored for decision support.

### ***The proposed approach: Program Generation***

Program generation is the process of production of programs by means of other programs where the latter are usually called program generators. In the literature of software engineering, this process is referred to as *automatic program generation*. It is concerned with approaches, techniques and tools for generating program source code which is subsequently compiled or interpreted.

### **Rough Set based Classification: Preliminaries**

In the literature many classification approaches have been proposed and implemented by researchers, such as, decision tree based classification, statistical classification, neural network based classification, genetic algorithms classifiers and rough set based classification [1, 13].

In rough set theory, objects are perceived through the information that is available about them, that is, through their values for a predetermined set of attributes. In the case of inexact information, one has to be able to give and reason about rough classifications of objects. Basically, rough set theory deals with the approximation of sets that are difficult to describe with the available information [5].

The structure of data is represented in the form of Decision System (DS). The decision system is a pair of the form  $DS = (U, A \cup \{d\})$ , where  $U$  is a nonempty finite set of objects called the Universe, while  $A$  is a nonempty finite set of attributes. Every attribute  $a \in A$  is a total function  $a:U \rightarrow Va$ , where  $Va$  is the set of allowable values for the attribute  $a$  (i.e, its values range). The attributes belonging to  $A$  are called conditional attributes while  $d$  is called decision attribute. An example of a decision system is presented in Table 1. The decision system  $S = (U, A \cup \{d\})$  consists of five objects  $U = \{x_1, \dots, x_5\}$ , five conditional attributes  $A = \{a_1, \dots, a_3\}$ , and one decision attribute  $\{d\}$ .

**Table 1:** A Decision System  $S$ .

| $x_i \in U$ | $a_1$ | $a_2$ | $a_3$ | $\Rightarrow$ | $d$      |
|-------------|-------|-------|-------|---------------|----------|
| $x_1$       | 1     | 2     | 3     |               | <b>1</b> |
| $x_2$       | 1     | 2     | 1     |               | <b>2</b> |
| $x_3$       | 2     | 2     | 3     |               | <b>2</b> |
| $x_4$       | 2     | 3     | 3     |               | <b>2</b> |
| $x_5$       | 3     | 5     | 1     |               | <b>3</b> |

**The Indiscernibility Relation**

For each possible subset of attributes  $B \subseteq A$ , a decision system gives rise to an equivalence relation called an Indiscernibility relation  $IND(B)$ , where two objects  $(x_i, x_j)$  are members of the same equivalence class if and only if they cannot be discerned from each other on the basis of the set of attributes  $B$ . The formal definition of  $IND(B)$  is expressed as:

$$IND(B) = \{(x_i, x_j) \in |U| \times |U| : a(x_i) = a(x_j) \forall a \in B\}.$$

The discernibility knowledge of the decision system is commonly recorded in a matrix called the discernibility matrix ( $DM$ ) (Liu and Lu, 2007). The  $DM$  is a symmetric  $|U| \times |U|$  matrix with entries  $[c_{ij}]$  defined as:

$$[c_{ij}] = \{a \in A \mid \text{if } a(x_i) \neq a(x_j)\} \quad \forall a \in A; \emptyset \text{ otherwise}$$

The entry  $c_{ij}$  of the  $DM$  contains all the attributes that differentiate between two given objects  $x_i$  and  $x_j$ .

**Attribute reduction**

The reduct concept of  $A$  refers to the minimal selection of attributes that preserves the Indiscernibility relation computed on the basis of the full set of attributes. Formally, a reduct of a decision system is any subset  $B \subseteq A \cup \{d\}$  such that  $IND(B) = IND(A)$  and  $IND(B - \{a\}) \neq IND(A)$  for every  $a \in B$ .

There are several approaches proposed in the literature to generate the set of reducts [14]. Some of these proposed techniques have used the discernibility matrix to generate reducts [15][16]. For the decision table presented in Table 1, the discernibility matrix and the set of object reducts of the decision system  $S$  are presented in Table 2.

**Table 2:** The Discernibility Matrix Modulo and the object Reducts.

|       | $x_1$         | $x_2$     | $x_3$         | $x_4$         | $x_5$         | <b>Obj Reducts</b>           |
|-------|---------------|-----------|---------------|---------------|---------------|------------------------------|
| $x_1$ | -             | $a_3$     | $a_1$         | $a_1 a_2$     | $a_1 a_2 a_3$ | $\{a_1, a_3\}$               |
| $x_2$ | $a_3$         | -         | -             | -             | $a_1 a_2$     | $\{a_1, a_3\}, \{a_2, a_3\}$ |
| $x_3$ | $a_1$         | -         | -             | -             | $a_1 a_2 a_3$ | $\{a_1\}$                    |
| $x_4$ | $a_1 a_2$     | -         | -             | -             | $a_1 a_2 a_3$ | $\{a_1\}, \{a_2\}$           |
| $x_5$ | $a_1 a_2 a_3$ | $a_1 a_2$ | $a_1 a_2 a_3$ | $a_1 a_2 a_3$ | -             | $\{a_1\}, \{a_2\}$           |

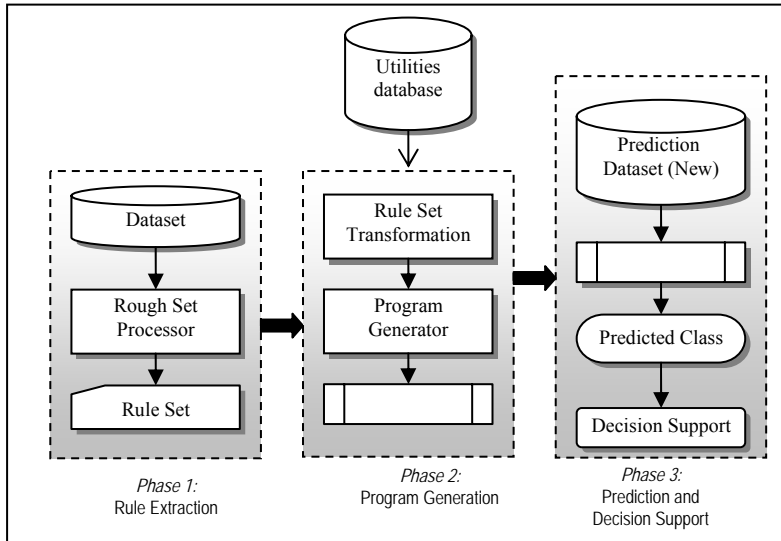
### Overview of the Proposed Approach

To link the proposed approach with the framework of Rough Set based classification, this research focuses on transforming the extracted rules out of the Rough Set based classification process into a program. The generated program will be ready to run and to be used by the decision maker to help in taking actions and decisions regarding any new case which is not used in the training and testing phases of the data mining process. An overall overview of the proposed module within the Rough Set based classification framework is presented in Figure 1.

The Rough Set based knowledge extraction system is equipped with a module that implements the transformation of the extracted rules into software components. The generated software (program) acts as a decision support system and the Rough Set theory is used as a knowledge acquisition tool. The correctness of the output of the software depends on the quality of the output of the data mining algorithm used to extract knowledge from data which is in our case the Rough Set theory.

Phase 1 represents the Rough Set based classification module. Practically, this module uses the entire dataset rather than the training dataset. The output of this module is the set of classification rules built out of the generated set of reducts. Table 3 shows the generated set of classification rules generated using the set of reducts presented in Table 2 for the decision system  $S$ .

The module that handles the process of transforming the extracted rules set into a program is presented in phase 2 in the figure. The set of rules generated from the Rough Set processor is passed to the program generation module which in turn transforms these rules into a set of *if-then* statement of the desired programming language. As a target language, the current version of the system can generate programs coded using C++ programming language. The generated code does not need to be embedded in any other programming language code.



**Figure 1:** The Flow Diagram of the Program Generation Process.

**Table 3:** Sample of the Rules Generated from the decision system S.

| Rule # | Rule                                    |
|--------|---|
| 1      | $(a_1=1) \wedge (a_3=3) \implies (d=1)$ |
| 2      | $(a_1=1) \wedge (a_3=1) \implies (d=2)$ |
| 3      | $(a_2=2) \wedge (a_3=1) \implies (d=2)$ |
| 4      | $(a_1=2) \implies (d=2)$                |
| 5      | $(a_1=3) \implies (d=3)$                |
| 6      | $(a_2=3) \implies (d=2)$                |
| 7      | $(a_2=5) \implies (d=3)$                |
| 8      | $(a_2=5) \implies (d=4)$                |

### **Rule Set Transformation**

The module transforms the generated rules into suitable equivalent *if-then* structures of a programming language. The *if-then* rule is represented in terms of conjunctions, disjunctions, and implications. Such rules can be written in precise logical notation using two predicates, antecedent and consequent. The syntax of the translated rule is presented in Figure 2. The rule is represented in the form of *If <conditions> Then <class>* form. The <conditions> part is the antecedent of the rule which is a logical combination of the conditional attributes (for instance: *term1 and term2 and...*). Each term is a triple <attribute, operator, value>, where the operator is the equality relational operator '='. The <class>, which is the consequent of the rule, contains the predicted class for the object whose attributes values satisfy the <conditions> part of the rule.

|  |
|--|
| <p><b>If-Statement::</b> <i>If &lt;conditions&gt; Then &lt;class&gt;</i><br/> <b>Condition::</b> <i>&lt;term&gt; and &lt;term&gt;</i><br/> <b>Term::</b> <i>&lt;term&gt;   Null</i><br/> <b>Term::</b> <i>attribute-name &lt;operator&gt; value</i><br/> <b>Operator::</b> <i>'='</i><br/> <b>Class::</b> <i>class-value</i></p> |
|--|

**Figure 2:** The Syntax of the *if-then* Rule

### ***Utilities and Structures***

Generally, a program is a function that takes some values, and calculates them, and then gives the results. To generate a complete and usable program, several constructs, variables, and modules are included in the program. Practically, the constructs depend on the information provided in the original decision table and the output of the Rough Set classification method and functions.

### ***Utility Functions***

The generated program includes the following main functions:

- Functions for setting and reading the values of each attribute necessary for decision making.
- A function for referencing the appropriate values of the decision attribute based on the rule set.
- A Driver function that controls the flow of the program and calls other functions.
- A utility function that provides some statistical information which is collected during the rule extraction phase. The statistics includes the number of extracted rules, the accuracy of the classification model, and the dataset dimension used to build the model.

### ***Variables and Data Structures***

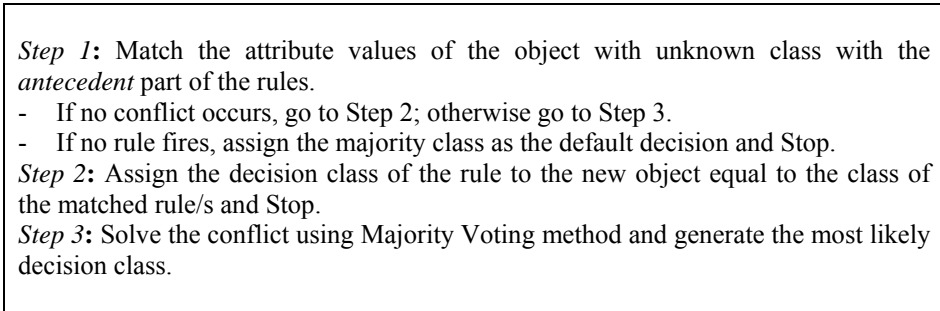
All the necessary constructs are embedded in the program including the internal variables representing the reduced conditional attributes set and the decision attributes. The data types of all attributes are extracted from the original decision table. The program includes an array data structure to control the voting mechanism necessary for referencing the appropriate values of the decision attribute based on the rule set.

### ***Prediction and Decision Support***

The process of using the generated code for decision support process is presented in Phase 3 in Figure 1. The user will provide the system (program) by the values of attributes of the new objects with unknown class and the system will find the best class for that object.

For the user convenience, the using of the system is facilitated by providing two alternative ways to classify the objects with unknown decision. In the first choice, the

user can predict the class for one database object by providing the values of the available condition attributes. The other choice, if the database objects (the prediction dataset) are stored in a table (file), the system will build a new table with the predicted class. The decision making mechanism provided in the program is summarized in the Figure 3.



**Figure 3:** The Decision Making Process.

## Conclusion

Knowledge Discovery in Database is an appealing approach to partially avoid the well-known knowledge acquisition bottleneck of expert systems, characterized by the time-consuming and costly task of acquiring knowledge from a domain expert. By automatic software construction relying on experimental data, great programming efforts could be saved.

This paper presented an approach to facilitate the usability of the extracted knowledge from the data mining classification task. The approach emphasizes the automated transformation of the decision rules extracted by Rough Sets based knowledge discovery systems into a usable decision making system. A model that implements the automated transformation of the extracted rules is embedded in the Rough Set based classification process. The current version of the model can generate programs coded in C++ programming language.

The model can be easily modified to generate programs in other programming languages. The model works with any data application as long as the data is presented in a decision system format. The new idea is presented within the framework of Rough Set theory based data classification; nevertheless the approach could be easily generalized to be used with any other knowledge discovery framework or methodology.

As a conclusion, the idea of generating a ready to run programs that manipulate the extracted rules is appealing and worth to be considered and adopted. Providing a code generation environment for the knowledge extraction process will facilitate the way to test the generated set of rules for new objects with unknown decision class. End users, who are not necessary computer experts, will be satisfied by using the generated system which facilitates the process of future decision making. We can claim that with this approach we are extending the main steps of KDD to include a new step that involves the processing of the extracted knowledge for the decision support purposes.

## طريقة مقترحة لتمثيل المعرفة المستخلصة من البيانات لتسهيل عملية اتخاذ القرار

قاسم أحمد الردايدة

### ملخص

حديثاً هناك اهتمام متنامي في مجال التنقيب في البيانات بهدف اكتشاف المعرفة وبحيث تكون هذه المعرفة صحيحة وشاملة وسهلة التحليل والفهم من قبل المستخدم النهائي. وعند بناء انظمة دعم القرار فان واحدة من اهم القضايا تتمثل في كيفية الحصول على البيانات والمعرفة وكذلك كيفية تمثيل هذه المعرفة. جاء هذا البحث لدعم هذه المسألة بان يسهل عملية البناء الاتوماتيكي لانظمة اتخاذ القرار مستخدماً تقنيات التنقيب في البيانات للحصول على المعرفة. في هذا البحث تم بناء نظام قادر على استخلاص قواعد التصنيف باستخدام نظرية المجموعات الخشنة، وهي احد الطرق المستخدمة لاستخلاص المعرفة، ومن ثم يتم تحويل هذه القواعد الى برنامج متكامل بشكل اتوماتيكي ليستخدم هذا البرنامج لاحقاً كأداة لتصنيف عناصر جديدة لتساعد في اتخاذ القرار المباشر. البرنامج الناتج مجهز بمجموعة من الاقترنات والاجراءات التي من شأنها تسهيل عمليات الادخال والاخراج والحصول على نتيجة التصنيف وحل التضارب بين قواعد التصنيف.

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## Sediments Transport across the Fringing Reef in the Gulf of Aqaba, Red Sea and the Implications on Live Corals

Nigem Ed-din Yusuf\*, Ahmed A. Al-Taani\*, Firas W. Al-Fukaha\*\*, Saeb A. Al-Shereideh\*  
and Mehaysen A. Mahasneh\*\*\*

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### Abstract

This study was conducted on the shallow fringing reef of Aqaba, Red Sea. Unconsolidated sediment samples were collected along two transects perpendicular to the coast to determine the pattern of grain size distribution across the reef complex. The iron, aluminum and strontium concentrations were used to delineate the reef topography and zonation. The results indicate that the grain size distribution depends upon the local rate of skeletal production, the prevailing hydrodynamic conditions and the rate of coarse terrigenous materials delivered to the reef. The main zones of sediment production are those exposed to the wave action, the reef flat and the reef edge. Deposition dominates in most sheltered fore reef zone. Fine materials produced on the reef flat find its way mainly to the fore reef, while the effect of terrigenous input is limited to the backreef zone. In the depositional zone, the sediments are mostly medium to coarse, poorly sorted and symmetrically skewed, while the reef flat is occupied by the coarsest sediments, poorly to moderately sorted and symmetrical in skewness. Iron and aluminum are mainly originated from terrigenous source and marked the backreef zone, while high concentration of strontium associated with carbonate indicate the fore reef and reef flat zones. Dumping of terrigenous materials associated with mud delivered by floods to the reef may negatively affect the live corals in the fore reef.

**Keywords:** Fringing reef, Aqaba, Unconsolidated sediments, Terrigenous sediment, Transport, Sediment texture.

### Introduction

Sedimentation and suspended sediments in the near shore reefs have been the focus of several geological studies. For a long time, classification of sediments based on composition and texture has been used to derive information about the hydrodynamic conditions under which resuspension, transport and deposition of sediments in modern environment occur. Recently, studies of hydrodynamic regime (waves, currents, tidal currents and suspended matters) have shifted from laboratory sediments analysis to field measurements. The results of field measurements indicated that the hydrodynamic characteristics and their relation to morphology and water depth, determine the regional

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\* Dept. of Earth and Environmental Sciences, Faculty of Science, Yarmouk University, Irbid 21163, Jordan.

\*\* Dept Weatherford International, Precision Energy Services, directional Drilling Dept., Saudi Arabia.

\*\*\* Al-Huson University Collage, Al Balqa Applied University, Irbid, Jordan.

dispersion of sediments and their availability in the near shore waters, and that they are acting at different degrees in space and time. While some studies have emphasized the regional importance of waves in generating turbidity and sediment transport [1, 2, 3 and 4], others indicated that the effect of waves in driving a net flux is relatively small, but the simultaneous presence of even a weak current will result in net transport [5].

Several studies emphasized the importance of tidal currents in resuspension of fine sediments in shallow waters [6, 7 and 8]. These studies have found that the magnitude of suspended sediments is predominantly controlled by wind generated waves, currents and tidal elevation on the reef flat. They also showed that the net influx of sediment is primarily occurring along the reef flat mainly in the direction of the prevailing winds. However, for better understanding of the modeling of sediments transport, current studies have included sediment characteristics in their models. Storlazzi *et al.* (2004) [9] suggested a model of water and fine-grained sediment transport across the fringing coral reef in Southern Molokai, where they found that wind generated waves across the reef flat increase the level of suspended sediments during flooding tides. As the tide falls, the water and associated sediments drain off across the reef flat and is advected offshore to the fore reef.

Few studies have been conducted on sediments composition and texture across the fringing reef at the eastern Red Sea coast ([10] in Jeddah, Saudi Arabia and [11] in the Gulf of Aqaba, Jordan). The first attempt to use sediment characteristics across the fringing reef to obtain information about the prevailing hydrodynamic regime was carried out by (Note 1) in the Gulf of Aqaba.

The coastal and marine environments along the Red Sea region are currently under increasing human pressure, which is likely to result in adverse environmental effects. Coastal development and artificial beaches in the Gulf of Aqaba have increased the delivered sediments. This has resulted in increased levels of suspended sediments which is likely to reduce light and affect the primary productivity and coral growth. In addition, sediments accumulation can eliminate recruitment sites, and even bury coral colonies [8, 12 and 13].

In this paper we describe the hydrodynamic regime in the near shore environment and the sediments characteristics of the fringing reef in Aqaba to better understand the distribution pattern of sediments. While the coral reef complex interacts with terrigenous sediments delivered from the coastal plain, it is important to identify the sediment sources, movement and their deposition across the reef. Since aluminum (Al) and iron (Fe) are the most commonly used indicator elements for the crustal source [14], their concentrations as well as calcium carbonate (CaCO<sub>3</sub>) and strontium (Sr) have been used as indicators of the relative contribution of terrestrial and marine sources to sediments.

## **Description of Study Area**

The Red Sea lies along deep rift valley, which has only a narrow and shallow natural connection to the Indian Ocean at Strait of Bab el-Mandib. The Gulf of Aqaba is the eastern segment of the V-shaped northern extension of the Red Sea (Fig. 1). It is about 170 km long with a maximum width of 25km, decreasing to about 5km at the northern tip. The maximum depth of the Gulf of Aqaba is about 2000 m, which is nearly

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as much as that of the Red Sea. In spite of this, it is considered a partially enclosed water body. It is connected to the Red Sea by the Strait of Tiran, which has a depth of about 252 m [15]. The shape, bathymetry and structure of the gulf resulted from Cenozoic breakup of the Arabian-African platform and the left-lateral strike-slip movement along the Dead Sea Transform. The Gulf of Aqaba is bordered by Precambrian basement, plutonic, and metamorphic rocks. Valleys flowing across the coastal plain and reaching the sea, cut the coastal mountains. The coastal plain is not well developed around the gulf, however, only along the southern and northern shores, where it extends to Wadi Araba; the coastal plain becomes relatively wide [16 and 17]. It comprises alluvial sediments delivered from the adjacent basement as well as from the elevated Pleistocene coral terraces in some locations. The sediments around the Gulf occur in the form of fans, dunes, sabkha, and beach sediments [17]. The floor of the Gulf of Aqaba inclines sharply seawards to reach a maximum depth of 2000 m in some places. The extensive shallow water zones on both flanks of the Gulf represent suitable habitat for the development of coral reefs which form the northernmost extension of coral reefs in the world.

### **Reef Topography and Zonation**

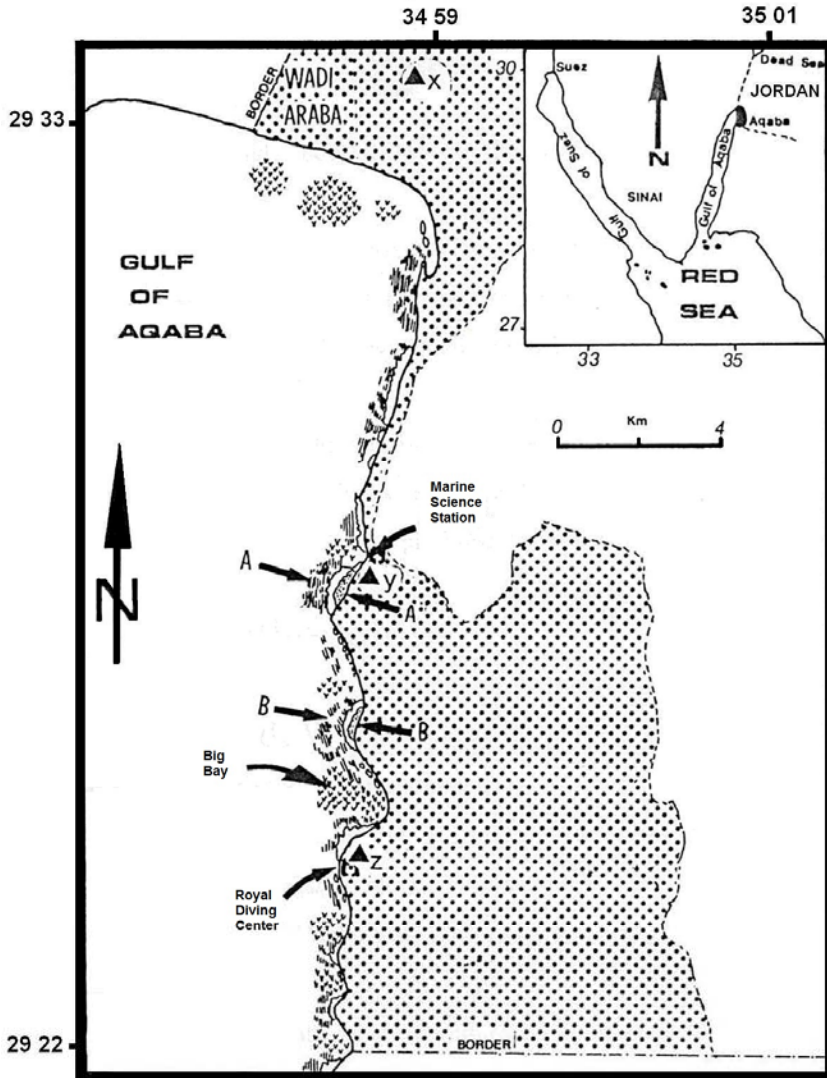
Nearly continuous marginal coral reefs are formed along most of the Jordanian coast of the Gulf. The fringing reef is well developed around the headlands and break up by the Wadi mouths, which deliver terrigenous sediments by floods from the surrounding basement rocks. Two fringing reefs south of Aqaba at site A and B are well developed. They are about 0.5 to 1 km long and 50 to 60 m wide. Reef profile and zonation of flora and fauna in the Gulf of Aqaba have been described by Bouchon et al., (1982) and Mergner (1984). The following zones can be distinguished seawards:

#### ***The Backreef Zone***

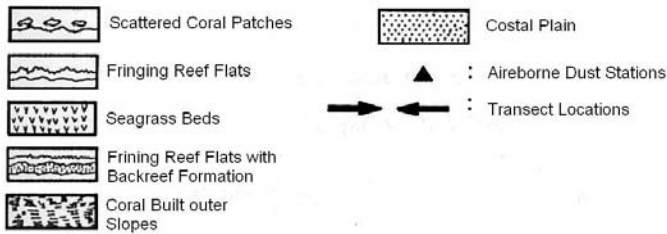
This zone is found where the reef complex is well developed. A platform, formed of rocks mostly on erosional surface of fossil backreef, but covered with varied veneer of medium grained sediments, provides a wide range of shallow subtidal habitats. These include coral gardens of stylophora, platygyra and millepora. Seagrass beds of *Halophila* form scattered vegetation on the very shallow sandy bottom (0.4 to 1 m below mean sea level). The intertidal zone is mainly formed of an erosional surface of old beaches and marks the landward part of the platform. It consists of lithified terrestrial coarse-grained sediments delivered from the surrounding basement rocks, with a seaward slope of 5 to 12%. Small pools retaining water when the tide ebbs, form suitable conditions for living fauna.

#### ***The Reef Flat zone***

It is about 20 m wide in a well-developed reef complex as is at the case site A. The reef flat is occupied by flourishing coral communities, but compared with the outer slope; they occur in small size colonies. Boat channels of 1.5 m deeper than the reef flat surface with minor sediments accumulation and scattered coral heads, occur in some areas south of Aqaba (at transect B), and connect the reef flat to the shoreline.



**LEGEND:**



**Fig. (1):** Location map and sampling sites.

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### ***The Fore Reef Zone***

This zone can be subdivided into two types: the first is a sand talus with a slope of about 20%. It occurs in the head of embayment at the Wadi mouths, where terrigenous inputs dominate. On this slope, seagrass beds are common but coral formation has not developed. With increasing distance from the axis of the Wadi mouths to the headlands, the coral heads and patches gradually replace the seagrass beds and become dominant where it extends to form the second type; the coral built for reef found at the headlands. In this type, the fore reef has a steep slope of 20 to 30% where depths of several hundred of meters are reached rapidly. In general, the diversity and species number increase seaward across the reef flat to the reef edge and continue downwards to 10 to 20 m depth, where the corals are highly flourished. The assemblages include more than 120 species [19].

### **Meteorology and Oceanography**

The Gulf of Aqaba is situated in a desert-belt area, bordered by the Sinai and Negev Deserts to the west and by the Arabian Desert to the east. Rainfall is very low and concentrated in short bursts between long rainless periods. This may result in moving huge amount of terrigenous materials by flash-floods from the adjacent basement to the sea.

The water temperature in the upper 200 m varies from 20°C in the winter to 26°C in the summer. The high evaporation rate of sea water (200–365 cm/year), sparse rainfall and negligible runoff, resulted in high salinity in the upper 200 m, where it ranges from 40.3 to 40.8 ‰ in the winter and from 40.5 to 46.6 ‰ in the summer [21, 22 and 23].

Sea conditions are normally calm most of the year with wave period of 2–3 second and wave height of less than 0.3 m. Southerly winter storms, initiated by Khamasin wind blowing in the early and late summer, generate large waves of higher than 2 m [24]. The major tide signals in the northern Gulf of Aqaba during all seasons, are diurnal and semidiurnal barotropic tides. The tidal range is between 0.3 to 1 m.

The main feature of the current pattern along the Jordanian coast of the Gulf during summer, autumn and winter seasons, is the presence of a constant south-southwestward moving currents at depth layer of 6 and 12 m, which are parallel to the prevailing winds. In spring season, abrupt changes in the current direction from southward to northward are observed [23].

### **Sampling and Experimental Analysis**

Twenty two samples were collected along two transects (A and B) perpendicular to the coast (Fig. 1). Samples were taken from the shallow parts of the reef (the reef flat and the shallow backreef) during low tide or by SCUBA diving along the outer slope. Following samples collection, the sediment samples were dried and split into two halves. One half was sieved by a vibrating granulometric column to obtain the particle size distribution. The grain-size fractions were expressed in a unit of weight percentage (Fig. 2, A and B). The other half of sample was disaggregated and pulverized to -100 mesh and heated in at 350°C for one hour to remove organic matter. An aliquot of each sample

was prepared with distilled water, digested, centrifuged and the aqueous solution of samples were analyzed for Fe, Al and Sr by atomic absorption spectrophotometer. The carbonate content was determined using the titration method [25].

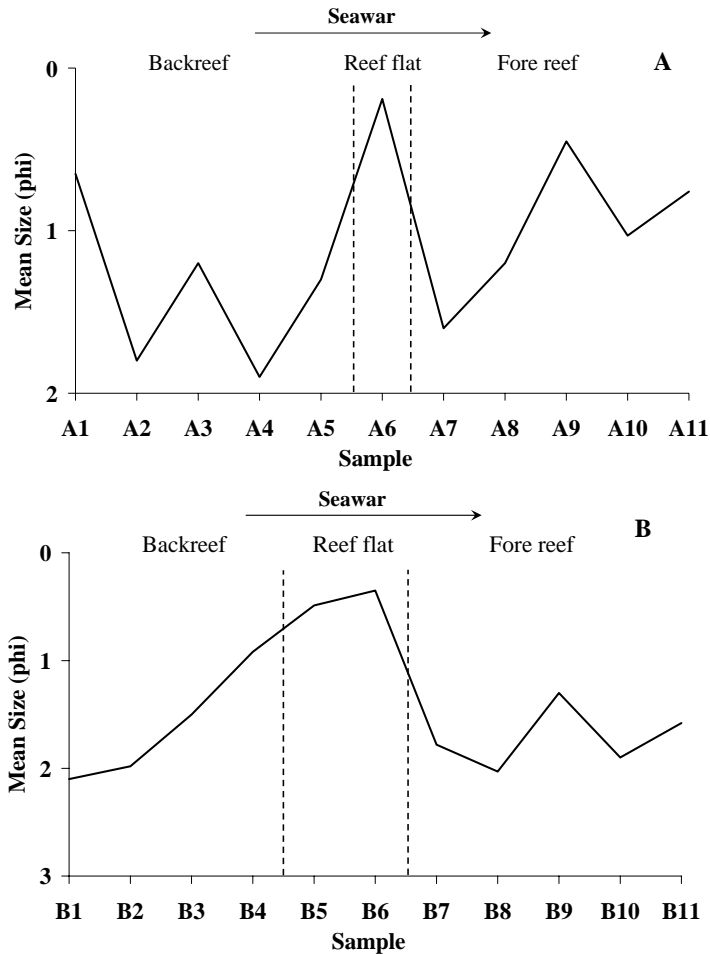


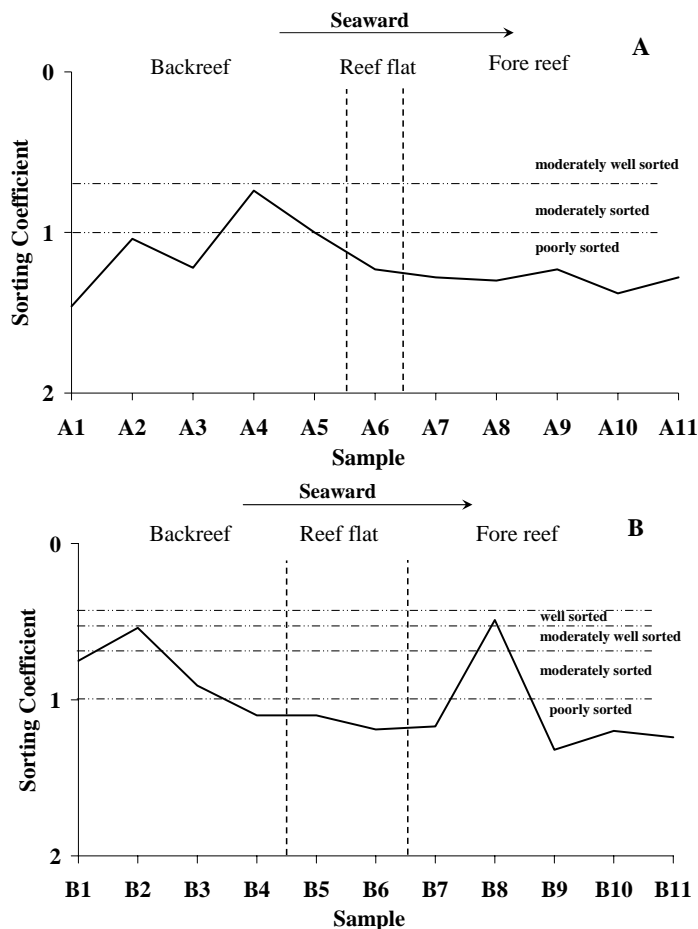
Fig. (2): Grain size distribution of samples collected from transects A and B.

## Results

### *Sediment Texture*

The sediments of the fore reef zone ranges in size between 2.03 to 0.45 phi (Fig. 2, A and B). They are mostly medium to coarse sand. The bulk of samples collected from the fore reef are poorly sorted (Fig. 3, A and B) and symmetrical in skewness (Fig. 4, A and B). The highest mud contents were observed in this zone with an average value of 5.6% in transect A and 7.5% in transect B (Fig. 5, A and B).

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**Fig. (3):** Sorting coefficient of samples collected from transects A and B.

The reef flat sediments are coarse to very coarse sands, with an average grain size ranging between 0.19 and 0.49 phi (Fig. 2, A and B). This zone is occupied by the coarsest sediments within the reef complex which are poorly to moderately sorted (Fig. 3, A and B) and symmetrical in skewness (Fig. 4, A and B). The sorting coefficient of the reef flat sediments ranges between 1.10 to 1.23 (Fig. 3, A and B). The low mud contents of the reef flat sediments range in average between 0.2% in A and 0.5% in B (Fig. 4, A and B).

The average grain-size of the backreef sediments varied from 0.65 and 2.10 phi (Fig. 2, A and B). In both transects, the sediments are mostly medium-sized and are poorly to moderately sorted (Fig. 3, A and B). The sorting coefficient ranges between 0.54 to 1.46. The majority of sediments of both transects tend to be strongly skewed (Fig. 4, A and B). The mud contents in both transects are low (Fig. 5, A and B).

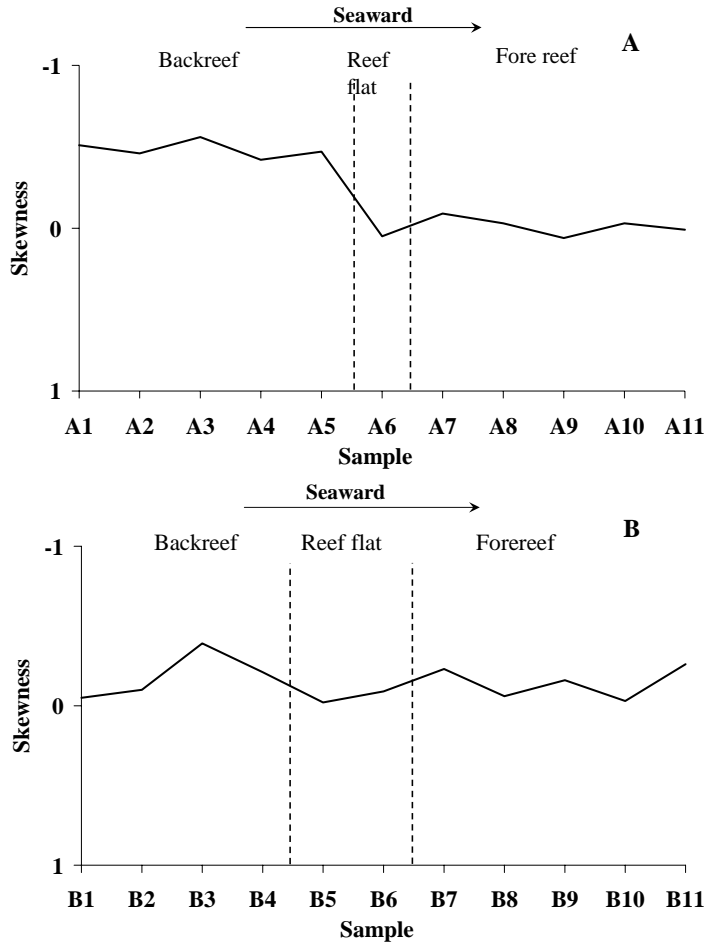


Fig. (4): Skewness of sediments collected from transects A and B.

### *Carbonate*

For both transects, the distribution of carbonate across the reef complex shows an increasing trend from the backreef to the fore reef. The lowest values were obtained near the shoreline, whereas the highest contents were observed within the fore reef zone (Fig. 5, A and B). In transect A, the carbonate values varied from 22% near the shoreline to 92% within the fore reef, whereas in transect B the values range from 37% near the shoreline to 82% in the fore reef zone (Fig. 5, A and B).

### *Mud*

Generally, the lowest mud content values obtained on the reef flat increase seaward to reach 5.6% in the inner fore reef sediment of transect A, and reach 7.53% in the outer fore reef in transect B. Slightly increasing tendency from the reef flat across the backreef to the shoreline can also be observed in both transects (Fig. 5).

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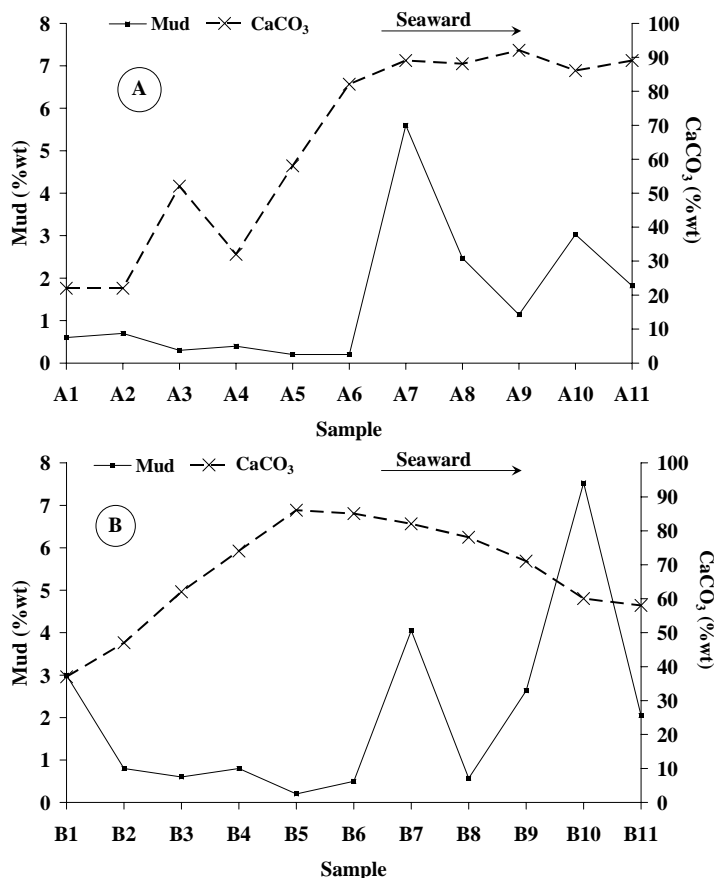
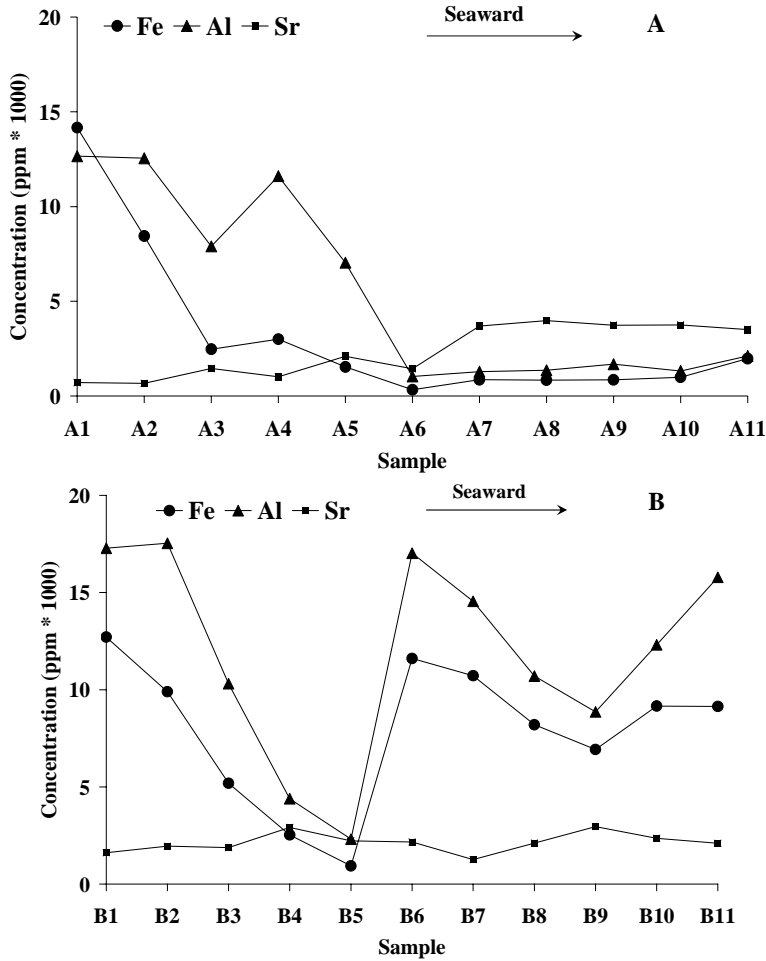


Fig. (5): Mud and calcium carbonate contents of samples collected from transects A and B.

**Major and Trace Elements**

The distribution pattern of Al and Fe shows a similar trend from the shoreline to the reef flat (Fig. 6, A and B). The highest values of 14163 and 12660 ppm were obtained in transects A and B respectively closer to the shoreline. The concentrations of both elements decreased gradually in A but abruptly in B across the backreef to reach the lowest values of 1029 ppm for Al and 327 ppm for Fe in the reef flat sediments (Fig. 6, A and B).

Toward the deeper water of the fore reef in transect A, a slight increase in the concentrations of Al was observed where they reached 2113 ppm in sample 11. However, Fe concentrations showed a markedly increasing tendency across the fore reef reaching a value of 1971 ppm in sample 11 (Fig. 6, A and B). In transect B, the distribution pattern of both elements is different. The concentrations increased abruptly from the reef flat to the fore reef and reached 15788 for Fe and 9138 ppm for Al in the sediments of the fore reef (Fig. 6, A and B).



**Fig. (6):** Distribution of Fe, Al and Sr in samples collected from transects A and B.

The distribution pattern of Sr generally showed an opposite trend compared with the distribution of Al and Fe. The lowest values of 709 and 1612 ppm were obtained close to the shoreline in both transects A and transect B respectively, while the highest values of 3974 and 2961 were observed in the fore reef sediments of both transects A and B respectively (Fig. 6, A and B).

## Discussion

### *Sediments Texture, Grain Size Distribution and Sorting*

The reef edge and reef flat are subjected to intensive waves and currents which provide a less permanent depositional environment. In addition to the biological destruction of coral communities flourishing at the reef edge and the outer reef flat, mechanical breakdown produces fragments and shingle indicating a passing phase in the

### **Sediments Transport across the Fringing Reef in the Gulf of Aqaba, Red Sea and the Implications on Live Corals**

sedimentary process. The transport of these materials to the fore reef base is normally small, which is enhanced under storm conditions. The seaward part of the reef flat was described by many authors as “boulder zone” [26, 27 and 28]. The following disintegration processes by wave action reduced most of the shingle to coarse and very coarse sand and most of the fragments to fine grades. In this regard, the reef flat acts as a reservoir of fine materials available for resuspension and is continuously washed out of the reef flat.

It is obvious that wave orbital velocity on the reef flat was generally insufficient to resuspend fine materials. The interaction of waves and current provided the stress capable of resuspending fine materials on the reef flat [3, 8 and 9]. This suggests that the greatest amount of resuspension occurred by the high tide coupled with waves (2 m high) generated by the relatively strong southerly winds. Under such conditions, the water becomes milky due to the huge amounts of suspended materials, even over the fore reef zone. As the tide falls, the sediment-rich water moves offshore to the relatively deep and calm water of the fore reef [8], leaving on the reef flat coarse to very coarse, poorly to moderately sorted and symmetrical sediments.

The poorly-sorted sediments of the reef flat indicate that the materials accumulated within this zone are still in the process of breakdown and transportation [29]. The transport of fine materials from the reef flat to the fore reef is the most likely the explanation for the relatively high mud content (3.4%) in this zone, in which weak tidal and subtidal currents allowed the fine materials to accumulate [6]. While the fore reef zone is affected by calm water conditions, coarsening of its sediments can be observed at depth greater than 10 m. This can only be explained by the contribution of unworked coarse and very coarse fragments produced mainly by mechanical destruction of corals, mollusks fragments and foraminiferal tests which have a wide range of grain size [11 and 18]. In the fore reef zone, sediments are further from the action of prevailing waves, which improves the sediments' sorting. This is in agreement with the results of [30 and 31] that shoaling waves as well as weak and irregular currents are responsible for the poorly sorted sediments.

The backreef zone is very shallow and almost barren. The majority of sediments within this zone are medium sand (Fig. 2, A and B) except for two samples. The coarsening character of sample A1, located close to the shoreline is most probably due to the input of relatively coarse terrigenous materials. This is evidenced by its low content of carbonate (22%). The coarsening in sample B4, located far from the shoreline is mostly due to damping of coarse unworked fragments and grains from the nearby lying reef flat. This is also supported by the high content of carbonate in this sample (74%). The coarsening of sediments at both ends of the backreef zone suggests an input of coarse materials from either the reef flat (biogenic skeletal materials) or the coastal area (terrigenous materials). However, the relatively low carbonate content of sediments in this zone, particularly in transect A, suggests that the transport of coarse materials from the reef flat to the backreef is very limited, whereas the transport of terrigenous materials to the backreef may extend to the reef flat (Fig. 2, A and B). This explanation is also supported by the low mud content of the backreef zone sediments. Mud generated in the

reef flat is mostly advected to the fore reef and very little may be transported to the backreef. It seems that the prevailing waves over the reef flat are incapable of moving even fine particles onshore to the backreef zone. The enrichment of sample B1 in mud-sized materials is most probably due to the presence of flourishing sea grasses at the site. Marine grasses are believed to be agents with ability to trap and bind silt and clay-sized particles [32].

It is also believed that the input of coarse terrigenous materials control the variations in textural properties of the backreef sediments. The dumping of coarse materials from land is more effective in transect A. It makes the granulometric curve of the effected sediments larger and hence they become poorly sorted. This explanation is supported by the variation in skewness values of sediments across the backreef zone in both transect. These values remain mostly constant across the backreef zone and increase in tendency to the reef flat, which indicate the influence of coarse terrigenous material influx to the backreef.

### *Geochemistry*

The behavior of Fe and Al in sediments across the reef complex was governed by the input of terrigenous material from the surrounding basement to the reef. This is indicated by the highest values of both elements closed to the shoreline (Fig. 6, A and B). The concentrations decrease across the backreef zone to the reef flat, where calcareous marine sediments dominate and the lowest values were observed.

In transect A, sample 6 from the reef flat contained the lowest values of both elements. The concentrations across the fore reef region remain nearly constant and appear to be within the values given by Graf (1960) for pure reef limestone and for Fe given by Milliman (1974) for an admixture of biogenic reefal sediments. This suggests that the effect of terrigenous input to Fe and Al concentrations is limited to the backreef zone, whereas the effect becomes minimal in the reef flat and fore reef sediments.

The distribution pattern of Fe and Al in transect B is similar to that of A, except across the fore reef zone, where the fore reef sediments are enriched in Fe and Al. The lowest values of both elements observed on the reef flat (sample 5) increase rapidly seaward across the fore reef. This indicates that significant amount of terrigenous materials were supplied to the fore reef.

In this area, storms are rare but they contributed a large proportion of the annual rainfall to the area. Following occasional heavy rains in the region, the normally dry valleys are filled with sediment-laden water which is discharged to the coast and reef system. The evidence of heavy rain is the reddish plume of flood discharged sediments from the adjacent high land, breaking the traffic roads, marking the reddish plume of pools in surface water which extend from the shoreline to the reef flat. The reef is significantly diminished along these wadis even at both sides in the fore reef zone. The suspended materials delivered to the water of the fore reef may then be transported through the moving current at depth layer of 6 to 12m [23] parallel to the coast. Great delivery of fine materials to the fore reef may lead to low coral coverage along the Jordanian coast, mainly by controlling the substrate, which is in agreement with Larcombe and Woolfe (1999a). Sediment also affect the structure and function of the

### **Sediments Transport across the Fringing Reef in the Gulf of Aqaba, Red Sea and the Implications on Live Corals**

reef ecosystem by influencing the numerous biological relationship occurring between fish, algae, sessile invertebrates and their coral habitat [36 and 37]. However it is important to monitor the recruitment rates of corals along the Aqaba coast to provide sufficient information for scientific-based decisions. The positive correlation between the concentrations of Fe and Al coupled with the mud content in transect B (the correlation becomes negative in transect A), indicate that both elements are associated with the mud content in transect B. It is obvious that the effect of mud, originated from terrigenous source, on the concentrations of both elements is limited only to the fore reef sediments.

The terrigenous origin of Fe and Al is also supported by the distribution of carbonates across the backreef in both transects. The highest values of carbonates in both transects were obtained on the reef flat and on the fore reef, decreased gradually across the backreef to the shoreline and probably reflect the dilution effect of terrigenous input from the coastal area. Consequently, the concentrations of both elements across the backreef zone as well as the difference in concentrations of both elements between the studied transects are most likely related to the proportion of the admixture of non-biogenic fragments. This may also explain the wide range of the results of many studies carried out in the Gulf of Aqaba and in similar areas around the Red Sea. The calcium carbonate obtained in this study range from 22% to 92.% with an average of 67.5% are close to those results reported by [38] for Al-Hurghada and the Gulf of Suez in Egypt. However, these values differ widely from those reported by [39] (57%) and by [40] (5%) for the northern tip of the Gulf of Aqaba. It must be noticed that the low values were observed in sediments near the mouth of Wadi Araba. It is obvious that the calcareous sediments at the northern tip of the Gulf are highly diluted by dumping of terrigenous materials via the Wadi Araba.

The behavior of Sr largely reflects the distribution of carbonates across the reef complex. The highest Sr values were obtained in sediments of the fore reef and reef flat (Fig. 6, A and B). The decreasing values of Sr within the backreef to the shoreline in transect A as well as the positively strong correlation between the carbonate content and Sr, indicate that the carbonate is a major source for Sr in the reefal sediments. In transect B, Sr values remain nearly constant across the reef complex to the shoreline. However, the relative low values of Sr in the fore reef sediments of transect B as well as the weak positive correlation between carbonate and Sr can only be explained by the contribution of terrigenous materials. Delivering of terrigenous materials associated with mud to the fore reef may also explain the high mud content (7.5%) obtained in the outer fore reef in transect B, while in transect A the mud content reach a maximum value of 5.5% in the fore reef sediments close to the reef flat (Fig. 5, A and B). This explanation is supported by the correlation between Sr and the mud content as well as between the mud content and carbonate. In transect A, the strong positive correlation between the mud content and Sr as well as the positive correlation between the carbonate and mud strongly indicate that the mud fraction in transect A is mostly originated from a biogenic source, while the negative correlations in transect B suggests a terrigenous origin. Recent carbonate reef with high Sr content is associated with aragonitic skeletal of corals. According to many authors [41, 42 and 43] the Sr values range between 7740 ppm in the Arabian Gulf and

7980 ppm in the Bahamas. The low Sr values obtained in this study can be explained by the proportion of the admixture of non-biogenic fragments. In addition, the varying proportion of the biogenic components, corals, mollusks, foraminiferal tests and coralline alga that make up the calcareous sediments, probably largely effect the Sr concentration in space and time. However, the average concentration of Sr agrees with the results reported by Friedman (1968) for reef sediments in the Gulf of Aqaba.

### **Conclusion**

The studied reef sediments are composed mainly of sand-sized material. The sediments are mostly poorly to moderately sorted and range in skewness from fine skewed to very coarse skewed. The calcium carbonate content is related to the proportion of non-biogenic materials. The carbonate content generally decreases towards the shoreline, while the terrigenous inputs decrease across the backreef to the reef flat.

Fe and Al concentrations are related to the amount of terrigenous materials delivered to the reef. Both elements decrease in concentrations seaward, while Sr which is associated with carbonate increases in the same direction. The concentrations of Fe and Al can be used to delineate the backreef, while Sr indicate the fore reef and reef flat zones.

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## نقل الرسوبيات على طول المرجان الحدي في خليج العقبة، البحر الأحمر وأهميتها في إدارة المنطقة الساحلية

نجم الدين يوسف، احمد عبد الكريم الطعاني، فراس الفقهاء، صائب شريدة ومحيسن محاسنة

### ملخص

أجريت هذه الدراسة على الشعاب المرجانية الحدية الضحلة لخليج العقبة، البحر الأحمر. حيث تم جمع عينات من الرواسب المفككة على طول اثنين من المقاطع العرضية، العمودية على الساحل لتحديد نمط توزيع أحجام الحبيبات عبر المجاميع المرجانية. تم استخدام تراكيز الحديد والألمنيوم والسترونشيوم لتحديد التضاريس والأنطقة للشهاب المرجانية. تشير النتائج إلى أن توزع حجم الحبيبات يتوقف على المعدل المحلي للإنتاج الهيكلي للشعب المرجانية، والظروف الهيدرودينامية السائدة بالإضافة لمعدل المواد القارية الخشنة الواصلة للشعب المرجانية. وبينت الدراسة بان المناطق الرئيسية لإنتاج الرسوبيات هي تلك التي تتعرض لفعل الأمواج بالإضافة لمسطح وحافة الشعاب المرجانية. يهيمن الترسيب على معظم منطقة مقدمة الشعاب المرجانية المحمية، حيث تصل معظم المواد الناعمة المنتجة على المسطحات المرجانية إلى منطقة مقدمة الشعاب، في حين يقتصر تأثير المواد القارية على منطقة الشعاب الخلفية. في منطقة الترسيب، تكون معظم الرواسب متوسطة إلى خشنة الحجم رديئة الفرز وذات انحراف متناظر، بينما تتميز المسطحات المرجانية برسوبيات خشنة رديئة إلى متوسطة الفرز ومتناظرة في الإنحراف. ينشأ الحديد والألمنيوم بشكل رئيسي من مصدر قاري بحيث يميز منطقة الشعاب الخلفية، في حين تشير نسبة السترونشيوم العالية والمرتبطة بالكربونات إلى مناطق مقدمة ومسطح الشعاب المرجانية. إلقاء المواد القارية بالإضافة للطين الواصل إلى الشعاب بفعل الفيضانات قد تؤثر سلبا على الشعاب المرجانية الحية في منطقة مقدمة الشعب المرجانية.

## Notes

Note 1: Al-Fukaha, F., A Textural and Geochemical Study on Reefal Sediments of the Gulf of Aqaba, and the Input of Airborne Dust to the Area. Unpublished MSc Thesis, Yarmouk University, Aqaba, Jordan, 1994.

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## Regression Analysis of Air Pollution in Marka Area – Jordan

Sana'a Odat\* and Ma'amoun Al- Jedaih\*\*

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### Abstract

In the present study, the relationship between average concentration of carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>) and hydrocarbons (HC) with meteorological factors, such as wind speed, wind direction, temperature, relative humidity and rainfall during the year 2005 was statistically analyzed using the stepwise multiple linear regression analysis.

According to the results obtained through analysis, higher CO, CO<sub>2</sub> and HC concentrations are strongly related to lower wind speed, lower degree of wind direction, colder temperatures, lower relative humidity and weakly lower rainfall. The statistical models of CO, CO<sub>2</sub> and HC including meteorological parameters gave  $R^2$  of 0.77, 0.85 and 0.83, respectively. Prediction equations were built for each pollutant concentrations in order to facilitate forecasting air quality using multiple regression analysis.

**Keywords:** Regression analysis; Air pollution; Exhaust emissions; Motor vehicles; Marka area; Meteorological parameters.

### Introduction

Air is an essential component of life on our planet. It supplies us with oxygen that is essential for our bodies to live and carbon dioxide that is essential for plants to make food. In the last 200 years or so, the growth in the world population and the industrial revolution has resulted in an increased demand for energy. Until now, these energy requirements have been supplied largely by the combustion of fossil fuels, the plant's resources of convenient carbonaceous fuel, coal and oil, have been used for heating purposes, power industry, transport and synthesis of chemicals. The by-products of these operations (particulates, the oxides of carbon, nitrogen and sulphur) have been emitted to the atmosphere in enormous quantities [1]. Air becomes polluted when it contains substances in quantities that could harm the comfort or health of humans and animals, or could damage plants or materials. These substances are called air pollutants and can be solid particles, liquid droplets or gases and they can occur naturally or as a result of human activity [2]. Air pollution from motor vehicles has become an important issue

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\* Department of Earth and Environmental Sciences, Faculty of Science, Yarmouk University, Irbid, Jordan.

\*\* Water and Environmental Engineering Department. Al- Balqa Applied University, Al-Huson College, Irbid, Jordan.

because increasing the number of vehicles in use has led to getting more and more pollution over the years.

Motor vehicles in Jordan contributed more than 20% of the total gases emissions during the year 2003 [3]. Number of motor vehicles in use of Jordan has increased from 318500 vehicles in the year 1998 to 679731 vehicles in the year 2005. One of the important environmental problems in Amman area, situated in central Jordan, has experiencing real air pollution problem. The problem is obvious from the haze that covers the area and from the unpleasant odor.

In this paper emission rates from motor vehicle in Marka area will be calculated and emission models will be developed for carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>) and hydrocarbons(HC) in terms of meteorological factors that affect their concentrations.

### **Data Collections:**

Given a set of observations from air monitoring and meteorological station, calculating statistical relationships among the variables is possible by using some statistical techniques such as regression analysis. Some statistical models, establish how close relationships are between concentration estimates and values actually measured under similar circumstances. Effects of all factors that determine atmospheric pollutant concentrations are implicitly accounted for in the air quality data used to develop and optimize the models. These models also have low development cost and resource requirements [4].

The purpose of this paper is to evaluate the changes of air quality in Marka area caused by motor vehicles and to investigate the correlation of CO, CO<sub>2</sub> and HC pollution in this area with meteorological parameters such as wind speed, wind direction, temperature, pressure, rainfall, sun radiation and relative humidity on daily basis during the year of 2005, where severe air pollution episodes occurred.

There have been several studies of the area examples of which the one conducted by the Ministry of Environment, Department of Motor Vehicles –Marka, based on the report issued by the station and Metrological department based on reports of metrological condition in Marka area during the year 2005. Concentrations were obtained by inserting a special probe into the exhaust while operating, and then the driver would be asked to increase the (rpm). Two types of gas analyzers were used AUTOCHEK 4/5 Analyzer, Nextech, Seoul, Korea, available at the Ministry of Environment–Amman /Jordan and Muller BEM Analyzer Type 8690, France, Available at Driving and Vehicles Licensing Department, Marka, Amman, Jordan.

The data were obtained from unpublished sources conducted by the Ministry of Environment, Department of Motor Vehicles –Amman, and Metrological department based on reports of metrological condition in Marka area during the period of (August 2005 –December 2005).

### **Data analysis**

CO, CO<sub>2</sub> and HC data together with meteorological parameters such as wind speed, temperature, relative humidity and pressure, were analyzed by multiple linear regression

using the SPSS version 11 and JMP and JMP IN Software version 4 [5]. CO, CO<sub>2</sub> and HC were considered as dependent variables while meteorological parameters such as wind speed, wind direction, temperature, relative humidity, solar radiation and rainfall were considered as independent variables.

Simple linear regression and multiple linear regressions are related statistical methods for modeling the relationship between two or more random variables using a linear equation. Simple linear regression refers to a regression between two variables while multiple regressions refers to a regression on more than two variables. Linear regression assumes the best estimate of the response is a linear function of some parameters (though not necessarily linear on the predictors), [6].

Linear regression analysis was used to quantify the associations among gaseous pollutant, particles and meteorological conditions. However, data which represents a time series need to be transformed and modeled to remove autocorrelation before regression analysis is applied in order to better satisfy the assumption that the error component of regression model is normally distributed and statistically independent. Multivariate linear – regression models were built to adjust the putative effects of metrological factors on air pollution variables. The forms and assumptions of the models were also analyzed to ensure normality in the distribution of the variables, homoscedasticity of variance, and independence. Throughout this study, statistical significance was determined at the 95% level. Stepwise regression models were used to analyze the data related to air pollution in order to determine the effect of metrological condition on the concentration of air pollutants according to this formula:

$$Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + \dots + b_n X_n \pm e$$

where Y is the concentration of air pollution with gases and particles, a is a constant b represents regression factor, X<sub>1</sub> – X<sub>n</sub> are independent variables that have effect on dependant ones, whereas, e is error deviation from mean [7].

The main goal of the statistical analysis is to forecast the air pollutants given the metrological condition. These models would help predicting air pollution status at certain meteorological condition.

The first stage of model development was the establishment of a correlation matrix for the different variables included in the study. The correlation matrix is used to select the independent variables that highly correlated with the dependent variable and to investigate the multicollinearity among the independent variables.

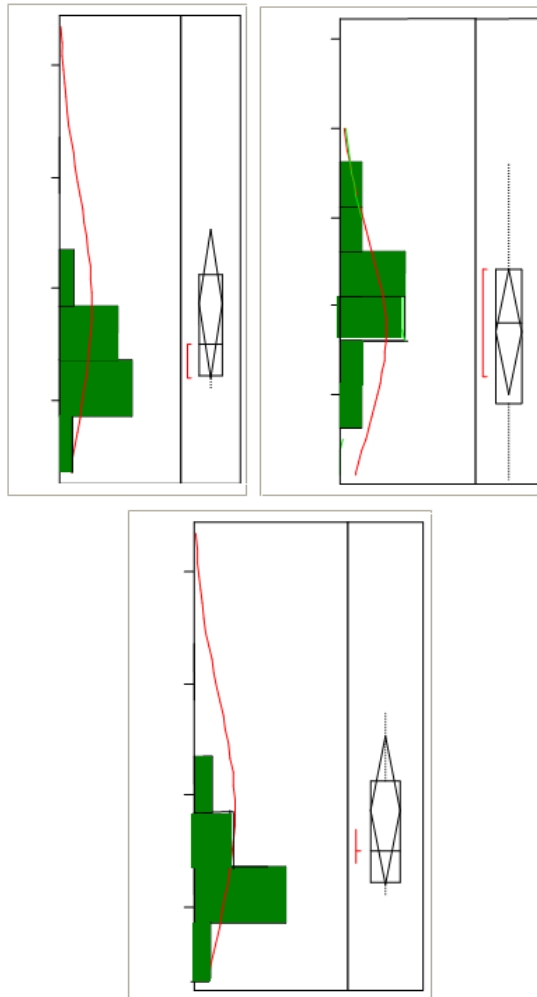
The second stage of model development was to perform linear and non-linear regression analysis in order to develop predictable models. The stepwise regression techniques were performed to select the best variables to enter the model. The stepwise regression procedure is built upon entering the independent variables that most highly correlated with the dependent variable. After that, the next variable is selected to enter the regression model using partial correlation coefficients. By mean of the partial F –test, each variable entered the model is examined at each step, then the regression models were developed as equations for the most independent variables that effect on dependent one.

**Results:**

**Distribution Analysis:**

The distributions of major emissions from large numbers of vehicles have relatively low emissions, while a relatively small number of malfunctioning vehicles have extremely high emissions. To overcome this difficulty, analysis have typically used the forms of the Log – normal [8] and gamma[9] distributions to model vehicle emissions data. One graphical tool for analyzing this kind of data is to plot emissions as a function of the cumulative fraction of vehicles [10].

As previously suggested, logarithmic transformation is frequently used to account for the non-normality of the data; yet this may not be the appropriate approach to take. Since the distribution of raw data significantly deviated from normality, (Figure 1).



**Fig. 1:** CO, CO<sub>2</sub> and HC distributions

### Evaluation of CO, CO<sub>2</sub> and HC concentrations and Meteorological Parameters during the Year 2005

Average emission rates of CO, CO<sub>2</sub> and HC concentrations from vehicle exhaust per liter of gasoline (g/l) and daily average meteorological parameters in 2005 are given in (Table 1).

**Table 1:** The means and standard deviations of CO,CO<sub>2</sub>, HC concentrations and meteorological parameters during the years of 2005.

|                                    | Mean    | Standard deviation |
|------------------------------------|---------|--------------------|
| CO concentration, g/l              | 299.97  | 96.3               |
| CO <sub>2</sub> concentration, g/l | 1802.61 | 128.2              |
| HC concentration, g/l              | 10.48   | 3.11               |
| Temperature, °C                    | 17.9    | 5.15               |
| Relative humidity %                | 63.83   | 11.53              |
| Wind Direction °                   | 279.4   | 81.31              |
| Rainfall, mm                       | 11.82   | 12.73              |
| Wind speed, m/s                    | 3.64    | 10.63              |
| Solar Radiation W/m <sup>2</sup>   | 2060.1  | 687.3              |

### Relationship between CO, CO<sub>2</sub>, HC and meteorological factors

The relationship between CO, CO<sub>2</sub>, HC and meteorological parameters (wind speed, wind direction, temperature, relative humidity and rainfall) during the year 2005 was investigated by stepwise multiple linear regression analysis. The correlations (R) between the average CO, CO<sub>2</sub>, HC concentrations and the average meteorological parameters are shown in Table 2. As seen in Table 2, Correlation coefficient for CO concentration shows the strong correlation with relative humidity, temperature, wind direction, rainfall and wind speed as thus: -0.34, -0.25, -0.20, -0.15 and -0.13 respectively and all these results are statistically significant at P less than 0.05. Whereas a strong correlation between the concentrations of CO<sub>2</sub> and temperature, where the correlation coefficient mounted up to -0.31. This value is significant at the 99% significance level. Relative humidity with a correlation of -0.33 in addition to the negative correlation between CO<sub>2</sub> and the factor of rainfall where the correlation coefficient reached -0.29. And for HC When we used “correlation analysis” to identify the factors most interrelated with the concentration of HC, relative humidity was the most related as the correlation coefficient was -0.55 followed by the factor of rainfall -0.34, Temperature 0.30, where all of them were statistically less than 0.05 (Table 2).

**Table 2:** Correlation Coefficient (R) and their probability for pollutants concentration levels and meteorological parameters.

| Variables           | W. S   | W.D   | T     | R.H   | Rainfall |
|---------------------|--------|-------|-------|-------|----------|
| CO <sub>2</sub> (R) | - 0.12 | 0.12  | -0.31 | -0.33 | -0.29    |
| P                   | 0.04   | 0.04  | 0.00  | 0.00  | 0.00     |
| CO (R)              | -0.13  | -0.20 | -0.25 | -0.34 | -0.15    |
| P                   | 0.04   | 0.002 | 0.00  | 0.089 | 0.021    |
| HC (R)              | -0.12  | 0.24  | 0.30  | -0.55 | -0.34    |
| P                   | 0.04   | 0.008 | 0.00  | 0.00  | 0.00     |

Note: R.H: Relative Humidity, W.S:Wind Speed W.D: Wind Direction, T: Temperature.

**The regression analysis:**

**Regressions Analysis of CO**

When we used the multiple regression analysis we found that all the independent variables involved in the analysis explain 0.77 out of the total difference in CO concentration,(Table 3), and that the factor of humidity was the most influential on the effect of CO, Based on this, we can write the prediction equation as follow:

**The concentration of CO = 0.423 – 0.0035 Humidity – 0.001 Rainfall – 0.0024 Temperature - 0.008 Wind speed – 0.00014 Wind direction. Eq. (1).**

**Table 3:** Statistical Characteristics of the model in Equation (1) for CO, a: Analysis of Variance and, b: Regression Analysis:

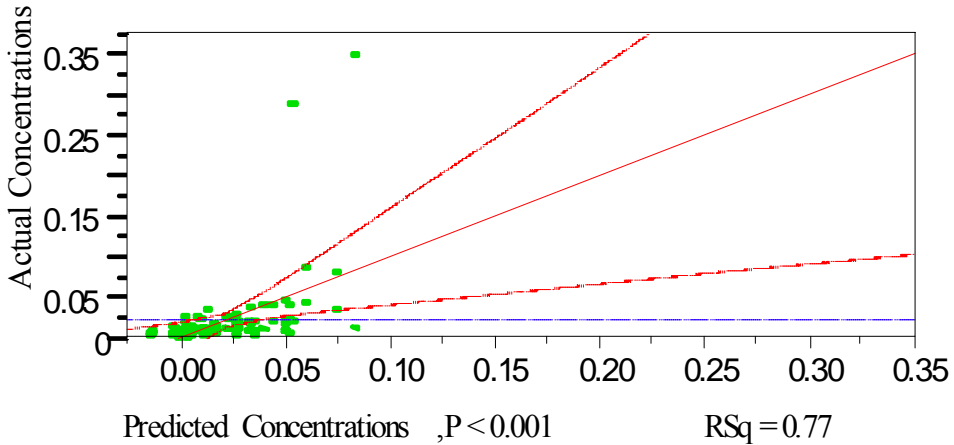
a-

| Source | DF | Sum of Squares | Mean Square | F Ratio               |
|--------|----|----------------|-------------|-----------------------|
| Model  | 8  | 0.05568834     | 0.005798    | 3.8639                |
| Error  | 85 | 0.2422283      | 0.001884    | R <sup>2</sup> = 0.77 |

b-

| Term           | Estimate   | Std Error | t Ratio | Prob> t |
|----------------|------------|-----------|---------|---------|
| Intercept      | 0.4336510  | 0.10601   | 3.87    | 0.0002  |
| Wind Speed     | -0.007990  | 0.00611   | -1.21   | 0.0032  |
| Wind Direction | -0.000141  | 0.000131  | -1.12   | 0.0276  |
| Temperature    | -0.00240   | 0.00231   | -1.05   | 0.0654  |
| Rainfall       | -0.0010095 | 0.00042   | -1.978  | 0.0523  |
| Humidity       | -0.003508  | 0.001023  | 3.35    | 0.0010  |

Acceptable α -level = 0.100, i.e., acceptable at the 90% significant α level.



**Fig. 2:** Estimated whole model of CO concentration versus meteorological condition

**Regressions Analysis of CO<sub>2</sub>**

Multiple regressions Analysis were used first to calculate the prediction equation for CO<sub>2</sub>, based on climate factors, (Fig. 2), followed by humidity then clouds. All variables were statistically significant at P less than 0.05. The other independent variables (temperature, the amount of the clouds, rainfall, wind speed and wind direction) contributed a lot in explaining the difference in CO<sub>2</sub> concentrations. Using Multiple Regression, meteorological factors explained 0.85 of the difference in the concentration of CO<sub>2</sub>. According to table (4), we can write the equation which predicts CO<sub>2</sub> concentration as follows:

$$\text{CO}_2 \text{ concentration} = -0.0281 - 0.0003 \text{ Relative humidity} - 1.1 \times 10^{-6} \text{ Rainfall} - 1.8 \times 10^{-5} \text{ Temperature} + 1.9 \times 10^{-5} \text{ wind direction} - 5 \times 10^{-4} \text{ wind speed Eq. (2)}$$

**Table 4:** Statistical Characteristics of the model in Equation (2) of CO<sub>2</sub>. a: Analysis of Variance, b: Regression Analysis

a.

| Source   | DF | Sum of Squares | Mean Square | F Ratio               |
|----------|----|----------------|-------------|-----------------------|
| Model    | 8  | 0.00564301     | 0.000783    | 1.1888                |
| Error    | 88 | 0.04774130     | 0.000575    | R <sup>2</sup> = 0.85 |
| C. Total | 95 | 0.05128444     |             |                       |

b.

| Term           | Estimate   | Std Error | t Ratio | Prob> t |
|----------------|------------|-----------|---------|---------|
| Intercept      | -0.0281    | 0.064856  | 0.46    | 0.0649  |
| Wind Speed     | -0.000500  | 0.003354  | -0.14   | 0.0898  |
| Wind Direction | 0.0000179  | 0.000065  | 0.25    | 0.0821  |
| Temperature    | -0.000019  | 0.00133   | 0.01    | 0.099   |
| Rainfall       | -0.0000011 | 0.000269  | -0.01   | 0.0998  |
| Humidity       | -0.000311  | 0.000564  | -0.65   | 0.0509  |

Acceptable α -level = 0.100, i.e., acceptable at the 90% significant α level.

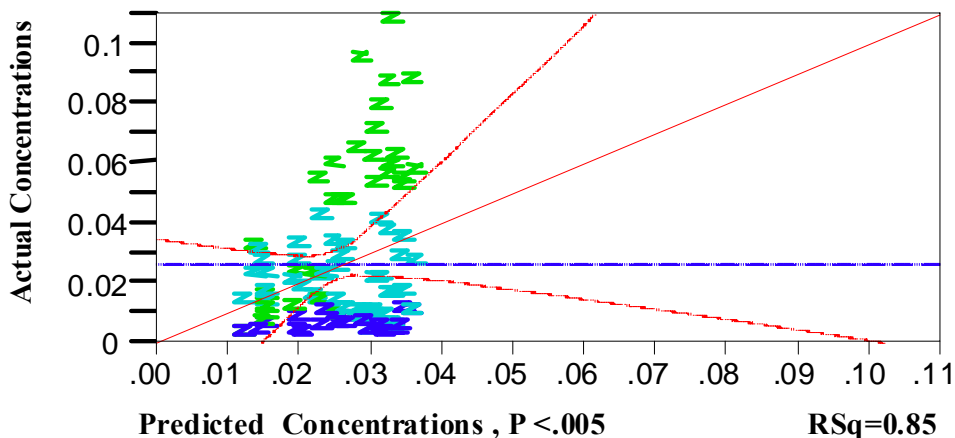


Fig. 3: Estimated whole model of CO<sub>2</sub> concentration versus meteorological conditions.

**Regressions Analysis of HC**

Using Multiple Regression, meteorological factors explained 0.83 of the difference in the concentration of HC. A model has been constructed to predict the concentrations of this pollutant depending on the effect of meteorological conditions as follows:

$$\text{Concentration of HC} = -71.2 + 1.39 \text{ wind direction} + 11.18 \text{ Temperature} - 2.8 \text{ Rainfall} - 3.97 \text{ humidity} - 11.7 \text{ wind speed. Eq. (3)}$$

The statistical characteristics of this model are summarized in Table 5. Figures 3 show the application of this model graphically.

**Table 5:** Statistical Characteristics of the model in Equation (3). Of HC a: Analysis of Variance, b: Regression Analysis

a.

| Source   | DF | Sum of Squares | Mean Square | F Ratio               |
|----------|----|----------------|-------------|-----------------------|
| Model    | 9  | 473936.9       | 67705.3     | 5.7528                |
| Error    | 71 | 619926.4       | 10332.1     | R <sup>2</sup> = 0.83 |
| C. Total | 89 | 1093863.3      |             |                       |

b.

| Term           | Estimate | Std Error | t Ratio | Prob> t |
|----------------|----------|-----------|---------|---------|
| Intercept      | -71.292  | 310.1825  | 0.25    | 0.0925  |
| Wind Speed     | -11.701  | 19.03079  | -0.52   | 0.0460  |
| Wind Direction | 1.389    | 0.364255  | 3.66    | 0.0002  |
| Temperature    | 11.1765  | 6.529595  | 1.68    | 0.0670  |
| Rainfall       | -2.8011  | 1.698858  | -1.45   | 0.0113  |
| Humidity       | -3.97    | 3.05118   | -1.33   | 0.0332  |

Acceptable  $\alpha$  -level = 0.100, i.e., acceptable at the 90% significant  $\alpha$  level.

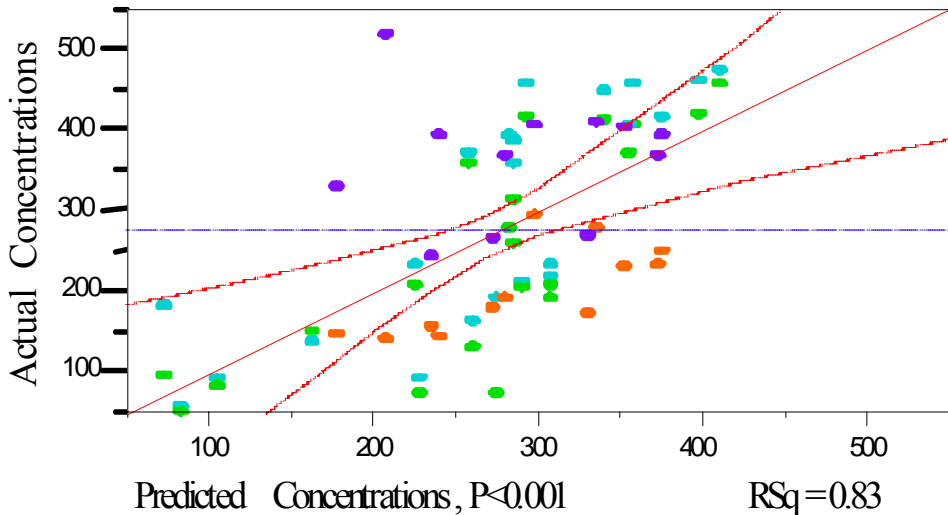


Fig. 4: Estimated whole model of HC concentration versus all meteorological conditions

**Discussions:**

**The Effect of Meteorological Conditions**

Air pollutants at receptor site are affected by transportation and perhaps transformation in the atmosphere. Location of the emission source, height and duration of release, as well as the amount of pollutants released are important. Experience shows that even when emission rate remain relatively steady for extended periods, a wide variation in gases concentrations from one day to the next can be observed[11]. These variations are generally due to changes in certain meteorological conditions.

From the knowledge of studies of various parameters of meteorology, we can predict dispersion of the pollutants in the atmosphere. Therefore, in order to understand air pollution surveillance and dispersion, we must understand the impact of the various meteorological parameters on the dispersion of air pollution. Such studies include consideration of wind, wind velocity, wind direction, effect of temperature, phenomena of inversion, relative humidity, etc.

The effect of metrological parameters on the ambient concentrations of the gases is discussed below:

***Rainfall***

The more the rainfall, the lower the concentration. The main reason for this relation is attributed to role of rain in cleaning the atmosphere’s pollutants and the fall of the acid rains. Marka area lacks this metrological factor, which could help in the concentrations of pollutants emitted from motor vehicles. Accordingly, rainfall has no effect on pollution concentrations in the study area.

### ***Temperature***

Temperature were found to show an inverse relation with the pollutants because of the role of the heat in warming up the surface of the earth by the oncoming radiation from the sun which strikes the earth and warms it, thus making the air that touch it warm and consequently reducing its density, so it expands and goes upward to be replaced by cold air and so on. This process increases the amounts of the up going air currents. When the horizontal and vertical air mixing processes increase, they reduce the concentration of the pollutants in it.

### ***Relative Humidity***

Humidity is low in Marka area. Its annual rate amount is 63%.The percent of humidity differs in seasons of winter and summer, where it reaches 56% in summer and 77% in winter. Also, the process of humidity decrease leads to more concentrations of gas. This paves the way for a suitable environment for certain photochemical interactions of the gases in which they change into different forms.

It has been evidenced from the results of this study that the relation of relative humidity with the concentration of the pollutants is a proportional one. This could be attributed to the role of humidity in causing heat discrepancies as the increase of humidity in the atmosphere will reduce the amount of solar radiation that reaches the earth. When sunshine collides with these drops, then it will absorb by these scattered drops in the surrounding atmosphere so they start to evaporate and launch its embedded heat in the surrounding air, which contributes in forming heat variations where the air near to the surface of the earth is becoming colder than that in the upper parts, thus reducing the up going air currents and accordingly increasing the pollutants in the atmosphere. Regarding the inverse relation with CO<sub>2</sub> this is due to what is performed by humidity in forming acid rain.

### ***Wind Currents***

Wind currents are caused by pressure differences, consequently leading the differences in temperature in the atmosphere. They can occur on large scale and lead to significant climatic changes. The intervening valley, trees, buildings can change their direction as well as their speed. Wind currents play a significant role in the distribution of pollutants in the atmosphere. In view of this, the changes in their velocity or direction and the impact of temperature on the course of their flow must be taken into consideration.

### ***Wind Speed:***

Pollutants are expected to be carried away and diluted during day times with high wind speeds. Low speed winds are prevailing in Marka area. The annual average speed is 3.7 knot that gradually decreases in winter to reach 1.6 knot. More than 50% of Marka area wind blow at speed between 4 – 8 knot and less than 10% has speed higher than 9 knot. This will play a role in having more concentration in gas in this area. It is not possible by any means for low speed winds to carry pollutants for further distance.

### ***Wind Direction***

The wind direction affects the ambient levels of the pollutants in the atmosphere. In order to obtain the wind directions in Marka area, the 0 –360 distributed wind direction data was divided into the eight main sectors; N,NE, E,SE,S,SW,W and NW. The western, and north-western directions are the most predominant wind directions in Marka area [12].

### **Conclusions:**

High air pollution took place in Marka area during the year 2005. The encountered high CO, CO<sub>2</sub> and HC values are due to low temperature, low wind speeds and the shortage of rainfall during most of winter season.

The results show a good relationship between the meteorological parameters and CO, CO<sub>2</sub> and HC in Marka area within the terms statistically analyzed. While pollutants concentrations have a strong relation with temperature, they have a significant correlation with wind speed. The precipitation and humidity is also weakly correlated with CO, CO<sub>2</sub>, and HC. In order to predict the CO,CO<sub>2</sub> and HC concentrations with regard to meteorological parameters, a statistical model was developed. The statistical model of CO, CO<sub>2</sub>, and HC including meteorological parameters gave  $R^2$  of 0.77, 0.85 and 0.83, respectively.

An understanding of pollution sources and emissions, and their interactions with the atmosphere, is the most important first step in developing appropriate air pollution management plans and action strategies. Without this type of knowledge, incorrect decision making related to air pollution management is possible, creating wasted resources and undesirable results[13]. Due to insufficiency of air quality information, strategic planning on air quality management is non-existent in Marka area. This study is only based on measurements made at one urban location. Undoubtedly, there is need for a more comprehensive study to improve the monitoring and evaluation systems for urban air pollution especially caused from motor vehicle emission, in greater Amman area.

### **Acknowledgments**

We thank the Ministry of Environment, Department of Driving and Vehicles Licensing and Department of Meteorology at Marka for providing us with the data used in this study.

## تحليل الانحدار لتلوث الهواء في منطقة ماركا - الأردن

سنة عودات ومأمون الجداية

### ملخص

تم في هذه الدراسة، دراسة العلاقة بين متوسط تركيز أول أكسيد الكربون (CO)، وثاني أكسيد الكربون (CO<sub>2</sub>) والهيدروكربونات (HC) وعوامل الأرصاد الجوية، مثل سرعة الرياح، اتجاه الرياح، درجة الحرارة، والرطوبة النسبية وكمية الأمطار في أثناء عام 2005 في منطقة عمان، وتم تحليلها إحصائياً باستخدام تحليل الانحدار الخطي والمتعدد.

وفقاً للنتائج التي تم الحصول عليها من خلال التحليل، تبين أن زيادة تركيز أول أكسيد الكربون (CO)، وثاني أكسيد الكربون (CO<sub>2</sub>) والهيدروكربونات (HC) ذات صلة بانخفاض سرعة الرياح وانخفاض درجة اتجاه الرياح ودرجات الحرارة والرطوبة النسبية وانخفاض هطول الأمطار. وأعطت النماذج الإحصائية للعلاقة بين تركيز أول أكسيد الكربون (CO)، وثاني أكسيد الكربون (CO<sub>2</sub>) والهيدروكربونات (HC) ومعلومات الأرصاد الجوية نتائج ذات دلالة إحصائية حيث بلغت  $(R^2)$  0.77، 0.85 و0.83 على التوالي.

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# Simultaneous Spectrophotometric Determination of Iron(II) and Total Iron Using Flow Injection Analysis

Abdulrahman S. Attiyat\*, Idrees F. Al-Momani\* and Mazen A. Moussa\*\*

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## Abstract

A rapid and sensitive method for the simultaneous determination of iron (II) and total iron is proposed. The method is based upon the injection of the sample mixture containing iron (II) and iron (III) into o-phenanthroline (o-phen) stream in citrate buffer at pH 3.7. The complex,  $[\text{Fe}(\text{o-phen})_3]^{2+}$ , resulting from the reaction of iron (II) with o-phenanthroline is rapidly formed and its absorbance is measured at the first flow cell at 510 nm. The stream passed through the first flow cell is mixed with hydroxylamine hydrochloride to reduce Fe(III) to Fe(II) before reaching the second flow cell. The produced  $\text{Fe}^{2+}$  is complexed by o-phenanthroline and the absorbance corresponding to the total concentration of Fe(II) and Fe(III) is monitored at the same wavelength in the second flow cell. Variables such as flow rate of reagents and other flow injection parameters were optimized to produce the most sensitive and reproducible results. The proposed method was successfully used for the simultaneous determination of Fe(II) and Fe(III) in soil and rock samples.

**Keywords:** Iron (II), Total iron, Spectrophotometric, Flow Injection Analysis.

## Introduction

The bioavailability and toxicity of metal species may depend on the lability and the chemical forms in which they are present. Iron is present as bivalent and trivalent states in natural waters and other terrestrial systems. Changes between these two forms of iron are important in various biological [1] and geochemical [2] processes.

Several procedures and techniques for the determination of Fe(II) and Fe(III) in different sample matrices have been reported in literature. However, voltammetric [3,4] and spectrophotometric [5-12] were the most widely used analytical techniques. Many of the reported spectrophotometric methods are based upon the use of packed columns for the simultaneous determination of Fe(II) and Fe(III) in mixtures [5-8]. Both cation- and anion-exchange columns were used for the on-line separation of the two ions [5,6]. The retained ions were then selectively eluted and detected through the reaction with a certain colorimetric reagent. In other cases, chelates formation were made first and the formed complexes were then separated by high pressure liquid chromatography using C18 columns [7,8].

Lunch et al [9] have used flow injection analysis (FIA) to determine iron (II) and iron (III) simultaneously by synchronized sample injection into two parallel flow systems. In this system iron (II) was reacted with o-phenathroline and iron (III) with thiocyanate. A flow injection method based upon the use of the same idea but different reagents was also described by Senior et al. [10]. In addition, catalytic methods for the determination of iron (II) and iron (III), based on catalysis of various redox reactions, were also reported [13-15]. Iron (II) and total iron were determined, simultaneously, using a flow injection procedure based on the catalytic effect of iron (II), on the oxidation of luminol, with hydrogen peroxide in alkaline medium [13].

This work describes the use of a sequentially arranged double flow cells system for the simultaneous determination of iron (II) and total iron. This system is based upon the use of both sample and reference cells of the double beam spectrophotometer in the FIA manifold. The system is much simpler and faster than most of systems described for the simultaneous determination of iron (II) and iron (III).

## Experimental

### Reagents

Analytical-reagent grade chemicals and deionized water were used to prepare all solutions. Citric acid, ammonium ferric sulphate, ammonium ferrous sulphate, sodium hydroxide, hydroxylamine hydrochloride (HAH), and o-phenanthroline were all obtained either from Fluka or from BDH Chemicals.

### Solutions

*Fe(II) stock solution:* A stock solution of 1000 ppm  $\text{Fe}^{2+}$ , was prepared by dissolving 7.021 g of  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot 6\text{H}_2\text{O}$  in 1.0 liter of 1.0 M hydrochloric acid.

*Hydroxylamine hydrochloride (HAH):* 0.2 M solution of HAH was prepared by dissolving 6.950 g in deionized water and diluting to 500 mL by deionized water.

*Fe(III) stock solution:* A stock solution of 1000 ppm  $\text{Fe}^{3+}$  was prepared by dissolving 8.633 g of  $\text{NH}_4\text{Fe}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$  in 1.0 liter of 1.0 M hydrochloric acid.

*Citrate buffer:* 1.910 g of citric acid (0.10 M citric acid) was dissolved in about 900 ml distilled water. The pH of the solution was then adjusted to 3.7 by 0.5 M NaOH and completed to 1.0 liter by distilled water.

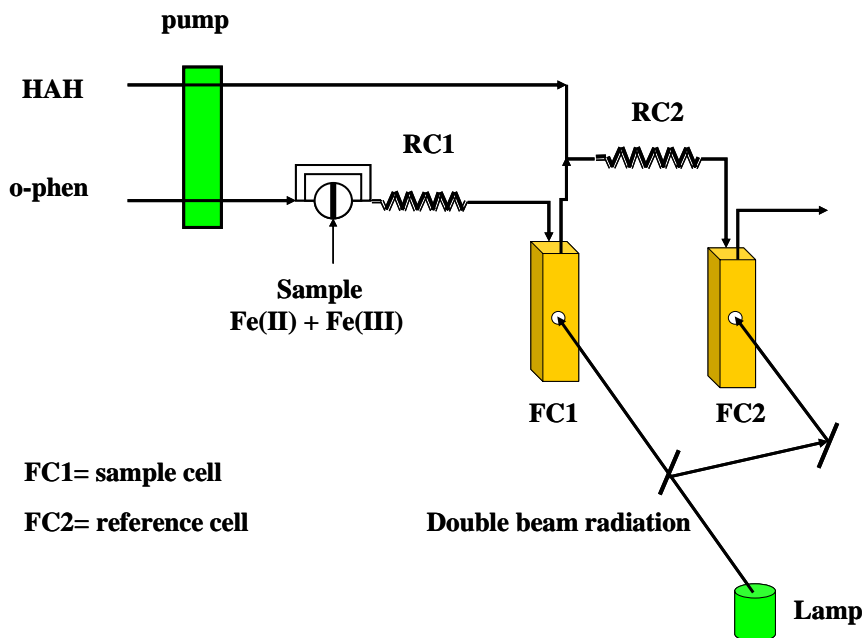
*o-phenanthroline solution:* A stock solution of 0.02 M was prepared by dissolving 3.965 g of o-phenanthroline in 1.0 liter of citrate buffer, pH 3.7.

*Standard solutions of Fe(II) and Fe(III):* These were prepared by mixing calculated volumes of Fe(II) and Fe(III) stock solutions and diluting to 100 mL by 1.0 M HCl. Calibration standard solutions containing 0.50 -15.0 ppm Fe(II) and 4.0 - 80.0 ppm Fe(III) were prepared.

*Soil and rock samples:* 2.0 g of grinded soil or rock samples were mixed with about 80 mL of 1.0 M HCl in a 150-mL beaker. The mixture was stirred for 10 hours and then allowed to stand for about 1 hour before filtration. Samples were filtered through Whatman filters first and then the filtrate was completed to volume (100-

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mL) by 1.0 M HCl solution. Fractions of these samples were transferred to Pyrex test tubes and irradiated by UV radiation for about 20 hours. Both irradiated and non-irradiated fractions were then filtered through 0.2  $\mu\text{m}$  syringe filters and 100  $\mu\text{L}$  volumes were injected into the manifold shown in Fig. 1.



**Fig. 1:** Flow diagram for the simultaneous determination of iron (II) and total iron. RC1, reaction coil-1; RC2, reaction coil-2; FC1, flow cell-1; FC2, flow cell-2.

### Apparatus

The manifold used in this work is shown in Fig. 1. A Rheodyne 6-way injection valve (Type 50) was used to introduce the sample into the carrier stream. Teflon tubing of 0.51 mm i.d. was used in the flow system. The length of the first reaction coil (RC1) was 40 cm, while the length of the second reaction coil (RC2) was 180 cm. The volume of the sample loop used was 100  $\mu\text{L}$ . A Varian DMS-100 UV-VIS double beam spectrophotometer connected to a linear 1200 recorder was used for the FI measurements. The wavelength was adjusted to 510 nm.

### General Procedure

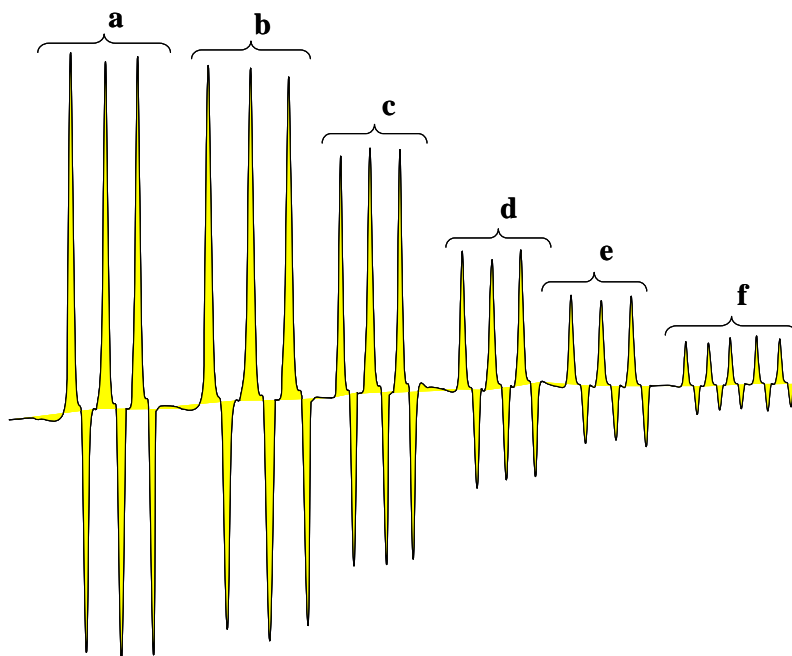
A double beam spectrophotometer was used in this work. Both the sample and the reference cells were used to measure iron(II) and total iron, respectively. A volume of 100  $\mu\text{L}$  of prepared sample solution containing Fe(II) and Fe(III) was loaded into the sample loop by means of a syringe. Samples were injected into o-phenanthroline stream pumped at a rate of 1.4 ml/min. Iron(II) in the sample is complexed with o-phenanthroline in RC1 to form the red complex,  $\text{Fe}(\text{o-phen})_3^{2+}$ . The absorbance of the formed complex was monitored in the first flow cell at 510 nm. The effluent from the

first flow cell is then merged with HAH at a rate of 1.4 ml/min to reduce Fe(III) to Fe(II) before entering the second flow cell (Fig. 1). The produced  $\text{Fe}^{2+}$  is then complexed with o-phenanthroline and the absorbance corresponding to total concentration of Fe(II) and Fe(III) was monitored in the second flow cell. After injection, the valve was returned to the load position when the maximum change in absorbance value has been reached. When the base line was reached, another slug of sample was injected.

## Results and Discussion

In this study, the heights of iron (II) and total iron peaks were measured. The optimal conditions for the simultaneous determination of iron (II) and total iron were established by varying one variable while keeping other variables constant. Several parameters including FIA and reaction variables were optimized in this work.

The proposed method is based upon the use of both sample and reference cells of the double beam spectrometer for the simultaneous determination of Fe(II) and total iron. As shown in Fig. 1, Fe(II), in the injected sample, reacts directly with the o-phenanthroline to form the red complex,  $\text{Fe}(\text{o-phen})_3^{2+}$ , which enters the first cell (FC1) to give a positive absorption peak. The stream, passed through FC1, is mixed with HAH, to reduce Fe(III) to Fe(II) before reaching the second flow cell (FC2). The produced Fe(II) is then complexed by o-phenanthroline and the absorbance corresponding to total concentrations of Fe(II) and Fe(III) is then recorded from cell-2 (FC2) to give a negative peak (Fig. 2).



**Fig. 2:** Typical flow signals for the determination of Fe (II) (positive peaks) and total iron (negative peaks) in synthetic mixtures. Concentrations of mixed samples solutions of Fe(II) + Fe(III) (ppm) were: (a), 2+10; (b), 3+20; (c), 4+15; (d), 5+10; (e), 3+30; (e), 3+10.

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The optimum flow rates and lengths of reaction coils were selected to obtain the maximum sensitivity for both analytes, taking into account that Fe(III) requires reduction prior to its reaction with o-phenanthroline. Moreover, we should remember that the observed absorbance reading is the result of the absorbance in the first flow cell minus the absorbance in the second flow cell ( $A_{FC1}-A_{FC2}$ ). Therefore, the second reaction coil (RC2) must be long enough to make sure that the colored complex,  $Fe(o\text{-phen})_3^{2+}$ , has completely left the first cell before reaching the second cell. Different lengths in the range of 50-250 cm were tested. Highest signals were obtained when the length of RC2 was 180 cm. The effect of the reaction coil (RC1) length on the analytical signal was also investigated. No significant changes were observed on the signals when the coil length changed in the range 10-60 cm.

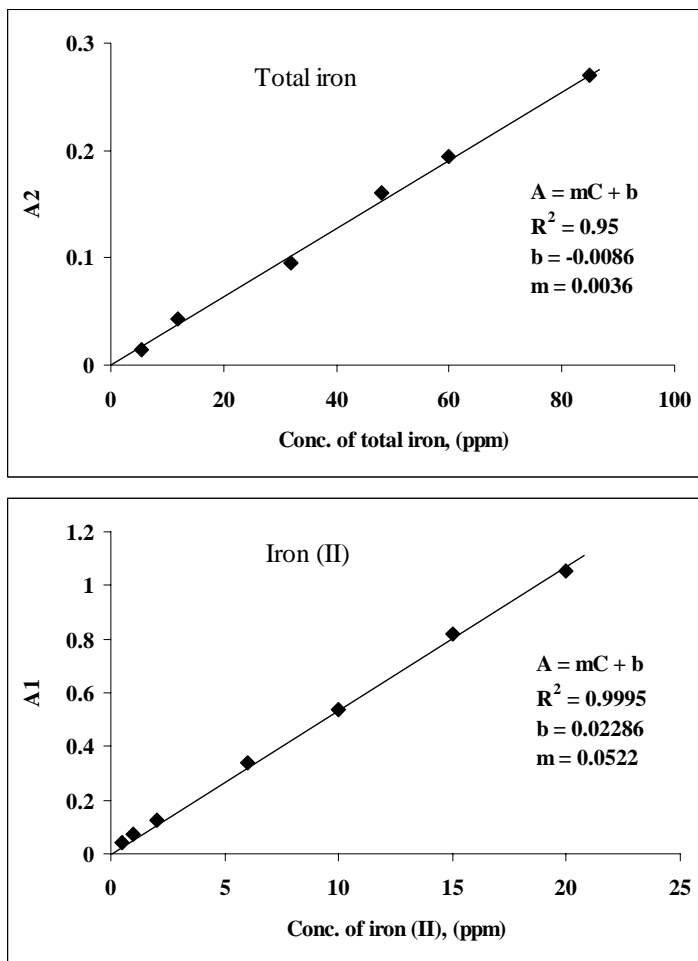
Similarly, different flow rates in the range 0.5-2.0 ml/min were tested in order to achieve maximum sensitivity and reasonable speed. A flow rate of 1.4 ml/min was selected for both reagents. At this flow rate, each injection requires about 80 seconds for the recorder pin to reach the base-line, which means that 45 measurements per hour can be injected using the proposed manifold. Table 1 gives the optimum values found for the studied variables using the same approach. Concentrations of reagents used were in excess compared to the concentration of the iron in the sample to ensure complete and quantitative reaction.

**Table 1:** Optimum FIA and reaction variables found

| Variable                        | Studied range | Selected value |
|---------------------------------|---------------|----------------|
| Injected volume, $\mu\text{L}$  | 50 – 250      | 100            |
| Reaction Coil (RC1), cm         | 30 – 100      | 40             |
| Reaction Coil (RC2), cm         | 50 - 250      | 180            |
| Flow Rate, $\text{ml min}^{-1}$ | 0.5 – 2.5     | 1.4            |
| pH of o-phen solution           | 2.0 - 4.5     | 3.7            |

### Evaluation of the Method

The calibration graphs for iron (II) and total iron were made using the proposed method and presented in Fig. 3. The calibration graphs were linear in the range of 0.5 to 12 ppm for iron (II) and 4 to 80 for total iron. The relative standard deviation (RSD) ( $n = 10$ ) was 2.5% for 2 ppm iron (II) and 1.9% for 10 ppm total iron.



**Fig. 3:** Calibration graphs for iron (II) and total iron.

To assess the accuracy of the proposed method for the simultaneous determination of iron (II) and total iron, synthetic mixtures containing known amounts of iron (II) and iron (III) were prepared. Concentrations of Fe(II) and Fe(III) found by the proposed FIA method are presented in Table 2. In this table, Fe(III) was calculated by difference [total iron – iron (II)]. As shown, concentrations found are in good agreement with the labeled concentrations with less than 5% error.

**Table 2:** Recoveries of Fe(II) and Fe(III) from synthetic mixtures.

| Added, ppm |         | Found, ppm |         | Recovery, % |         |
|------------|---------|------------|---------|-------------|---------|
| Fe(II)     | Fe(III) | Fe(II)     | Fe(III) | Fe(II)      | Fe(III) |
| 2.00       | 10.00   | 2.03       | 10.22   | 101.5       | 102.2   |
| 2.00       | 30.00   | 2.07       | 30.17   | 103.5       | 100.6   |
| 6.00       | 45.00   | 5.92       | 44.73   | 98.7        | 99.4    |

### Simultaneous Spectrophotometric Determination of Iron (II) and Total Iron Using Flow Injection Analysis

In order to test the applicability of the proposed FIA procedure for real samples, soil and rock samples were analyzed using the manifold shown in Fig. 1. Iron (II) and iron (III) in two soil and two rock samples were extracted using 1M HCl and then diluted to 100-mL with 1 M HCl. Iron (II) and iron (III) contents in these samples were determined by the proposed method and the results are given in Table 3, together with those obtained by using flame atomic absorption spectroscopy (AAS). As shown, the results obtained for total iron are lower than those obtained by AAS for the same samples. These results were not surprising because it is expected that some of the iron in these samples are not free for the direct reaction with o-phen. Actually, organic and humic substances are working as efficient chelating agents that hold up iron ions from reacting with the o-phen. This was simply tested by treating the extracted samples with o-phen or 1,10-ph/HAH mixtures in a test tube. Small amounts of the  $\text{Fe}(\text{ph})_3^{2+}$  complex were formed as indicated by the slight color changes. However, the color intensity was increasing with time, indicating a slow release for the Fe(II) and/or Fe(III) from the sample matrix. Therefore, the observed concentrations are considered to be as the labile or the acid extractable fraction of the iron. In order to make sure that these results are correct comparing to those obtained by the AAS, these organic and humic substances were destroyed by UV light. A strong UV radiation was used to destroy the humic substances and subsequently to release iron ions. After 20 hours of irradiation, soil and rock samples were then analyzed by the proposed method and results are compared with those obtained using AAS method (Table 3). No significant differences between the results of the proposed FIA method and AAS for total iron were observed. These results reinforce our previous finding about the accuracy and the applicability of the proposed method.

**Table 3:** Simultaneous determination of Fe(II) and Fe(III) in soil and rock samples.

| Sample                               | Proposed FIA procedure |                   |                 | AAS             |
|--------------------------------------|------------------------|-------------------|-----------------|-----------------|
|                                      | Fe(II)<br>(mg/g)       | Fe(III)<br>(mg/g) | Total<br>(mg/g) | Total<br>(mg/g) |
| <b>a. Before irradiation with UV</b> |                        |                   |                 |                 |
| Rock-1                               | 0.05                   | 1.11              | 1.17            | 2.01            |
| Rock-2                               | 6.50                   | 22.84             | 29.34           | 37.74           |
| Soil-1                               | 0.06                   | 1.06              | 1.11            | 1.75            |
| Soil-2                               | 0.58                   | 6.82              | 7.40            | 8.60            |
| <b>b. After irradiation with UV</b>  |                        |                   |                 |                 |
| Rock-1                               | 0.15                   | 1.80              | 1.95            | 2.01            |
| Rock-2                               | 7.61                   | 30.80             | 38.41           | 37.74           |
| Soil-1                               | 0.12                   | 1.57              | 1.69            | 1.75            |
| Soil-2                               | 1.01                   | 7.43              | 8.44            | 8.62            |

In conclusion, the proposed FI procedure has been successfully used for the analysis of synthetic and real samples containing iron (II) and iron (III). The method is very simple, using minimum number of reagents and reaction sequence. The speed of analysis and the precision make this method also suitable for the routine analysis of samples containing iron (II) and iron (III), replacing many of the tedious and expensive methods.

## Acknowledgements

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## التقدير الطيفي الآني للحديد الثنائي والحديد الكلي باستخدام الحقن بالجريان

عبدالرحمن عطيات و إدريس المومني و مازن موسى

### ملخص

في هذا البحث تم تطوير طريقة حساسة وسريعة لتقدير كل من ايون الحديد الثنائي والحديد الكلي (الثنائي + الثلاثي) في أن واحد. اعتمدت الطريقة المقترحة على حقن العينة التي تحتوي ايونات الحديد الثنائي والثلاثي في سيل من محلول اورثوفينانثرولين عند درجة الحموضة 3.7. يقاس امتصاص المعقد الناتج من تفاعل الحديد الثنائي مع مادة اورثوفينانثرولين  $[Fe(o-phen)_3^{2+}]$  في خلية الجريان الأولى عند طول الموجة 510 نانوميتر. بعد خروج العينة من الخلية الأولى، يضاف محلول هيدروكسيل امين هيدروكلوريد لاختزال الحديد الثلاثي إلى ثنائي وذلك قبل دخول الخلية الثانية. الحديد الثنائي المتكون في هذه الخطوة يتفاعل مع مادة اورثوفينانثرولين حيث يقاس امتصاص المعقد  $[Fe(o-phen)_3^{2+}]$  في الخلية الثانية. الامتصاص المقاس في الخلية الثانية يمثل الامتصاص الكلي الناتج من تفاعل الحديد الثنائي والحديد الثلاثي (بعد اختزاله) مع مادة اورثوفينانثرولين. المتغيرات المتعلقة بمعدلات التدفق للمحاليل المختلفة وكذلك متغيرات الحقن بالجريان الأخرى تم ضبطها للحصول على أفضل النتائج. الطريقة المقترحة في هذه الدراسة تم استخدامها بنجاح لتقدير الحديد الثنائي والحديد الثلاثي في أن واحد في عينات من الصخور والتربة.

الكلمات المفتاحية: الحديد الثنائي، الحديد الكلي، طيف الامتصاص، الحقن بالجريان.

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## Preparation and Investigation of the Magnetic Properties of Barium Hexaferrite Doped with Antimony

I. Bsoul and M. Al Zyoud \*

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### Abstract

Barium hexaferrite doped with different amounts of Sb in the form  $BaFe_{12-x}Sb_xO_{19}$  ( $x=0.0-0.6$ ) have been prepared using ball milling method. It was found that saturation magnetization increases in the concentration range up to  $x=0.3$  then saturation magnetization drops from 62.5 emu/g for  $x=0.3$  to 51.5 emu/g for  $x=0.6$ , while a reduction in coercive field was detected for all concentration examined. Such reduction in the coercive field was attributed to the decrease in magnetic anisotropy field. It was found that  $\delta m$  curves are negative for both pure and doped barium ferrite samples. Also it was found that  $\delta m$  value for the pure sample is greater (in the negative direction) than for those doped with Sb, which suggests that doping with Sb leads to decrease in the process of clusters formation.

**Keywords:** Barium hexaferrite; Coercivity; Saturation magnetization; Anisotropy field.

### Introduction

Barium hexaferrite with a chemical formula  $BaFe_{12}O_{19}$  is one of the most important composition for perpendicular magnetic recording. Barium hexaferrite is suitable for magnetic recording due to its large saturation magnetization, good chemical stability, and low switching field distribution. On the other hand, barium hexaferrite can be used for high density magnetic recording if its particle size and its large anisotropy field were decreased. Large particle size and high anisotropy field cause a poor overwrite modulation [1]. In order to reduce the anisotropy field and to satisfy the dessert applications, many studies were taken out to modify the magnetic properties of barium hexaferrite by the substitution of the  $Fe^{3+}$  ions with cations such as ( $Sn^{4+}, Ni^{2+}, Ni^{3+}, Co^{2+}, Co^{3+}, Ti^{4+}, etc.$ ) [2, 3, 4] or cations combinations such as (Zn-Sn, Co-Sn [5, 6], Zn-Ti [7], Co-Ti [2], etc.).

Several techniques can be used to prepare barium ferrite powders such as the sol-gel method [8-10], the glass crystallization method [11], hydrothermal technique [12], and coprecipitation method [13].

In the present work ball milling method was used to synthesize substituted barium hexaferrite powder ( $BaFe_{12-x}Sb_xO_{19}$ ). The preparation and investigation of barium ferrite doped with Sb -to the knowledge of others- has not been performed yet. So in this work we have investigated the possibility of introducing dopants ions such as Sb by the ball milling route.

Neutron diffraction study shows that the structure of  $BaFe_{12}O_{19}$  is of the form  $RSR^*S^*$ , Where  $R^*$  and  $S^*$  are obtained from the blocks R and S, by rotation of  $180^\circ$  around the hexagonal c axis [14-16]. The ferric ions are distributed among five crystallographic sites, three are octahedral sites ( $12k$ ,  $4f_2$ , and  $2a$ ), one is tetrahedral site ( $4f_1$ ) and one trigonal bipyramid ( $2b$ ) [17-19].

### Experimental procedures

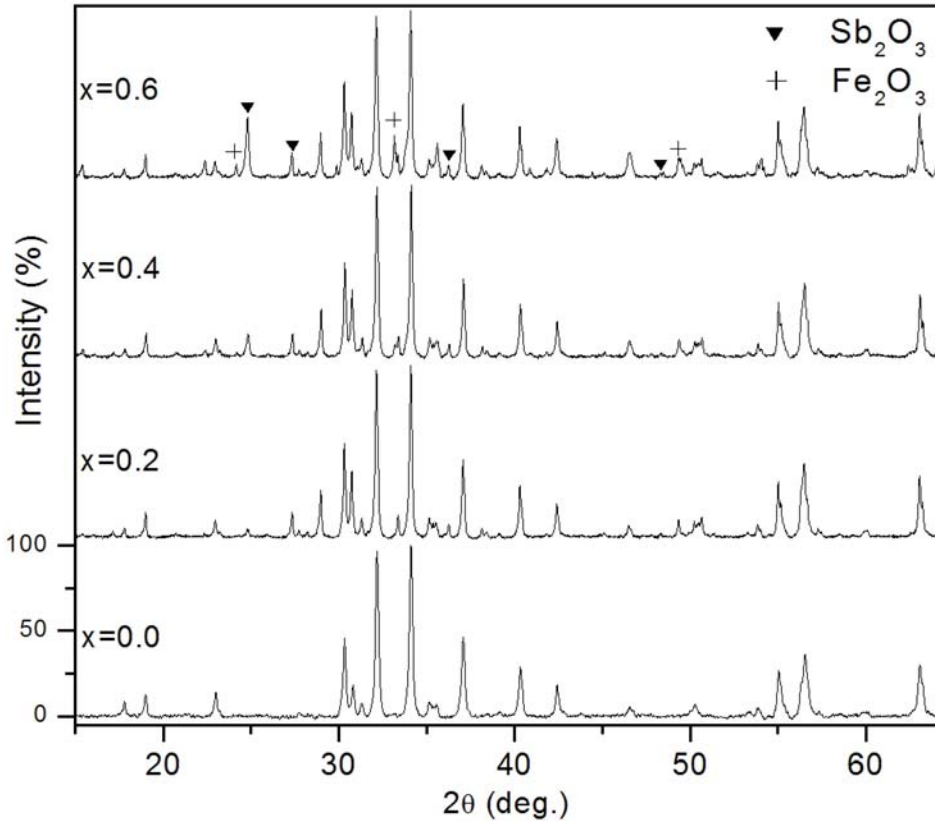
The starting materials for synthesis of  $BaFe_{12-x}Sb_xO_{19}$  ( $x=0, 0.1, 0.2, 0.3, 0.4, 0.5$  and  $0.6$ ) were  $BaCO_3$ ,  $Fe_2O_3$ , and  $Sb_2O_3$  (all are Aldrich-make).  $BaFe_{12-x}Sb_xO_{19}$  compound was prepared in a planetary ball-mill (Fritsch Pulverisette 7) with balls and vial of hardened steel. The milling experiment was carried out at 250 rpm for 16 h and the ball to powder ratio was 8:1. The as-milled powders were annealed in air atmosphere at  $1100^\circ C$  for 5 h. It should be noted that XRD analyses of more than 6 samples subjected to different annealing temperatures from  $700^\circ C$  to  $1200^\circ C$  revealed that the optimum annealing temperature for obtaining barium ferrite doped with Sb was  $1100^\circ C$ . X-ray diffraction (XRD) analysis was carried out in Philips X'Pert PRO X-ray diffractometer (PW3040/60) with  $CuK_\alpha$  radiation (45kV, 40 mA). The magnetic measurements were carried out using vibrating sample magnetometer (VSM) (MicroMag 3900, Princeton Measurements Corporation), with 10 kOe maximum applied field. All magnetic measurements were performed at room temperature.

### Results and discussion

XRD patterns for some samples examined in this work are represented in Fig. 1. All unmarked peaks belong to hexagonal barium ferrite ( $BaFe_{12}O_{19}$ ). XRD pattern for the sample ( $x=0.0$ ) shows XRD pattern which belongs to almost single phase of  $BaFe_{12}O_{19}$ . The XRD patterns of doped barium ferrite contain characteristic peaks of some traces of hematite ( $Fe_2O_3$ ) and antimony oxide ( $Sb_2O_3$ ). The intensities of XRD peaks of such traces were increased with the increase of Sb content in the sample.

Lattice parameters  $a$ ,  $c$  of  $BaFe_{12-x}Sb_xO_{19}$  were calculated according to formula 1 [20], where  $d$  is interplanar distance and  $h$ ,  $k$ , and  $l$  are Miller indices.

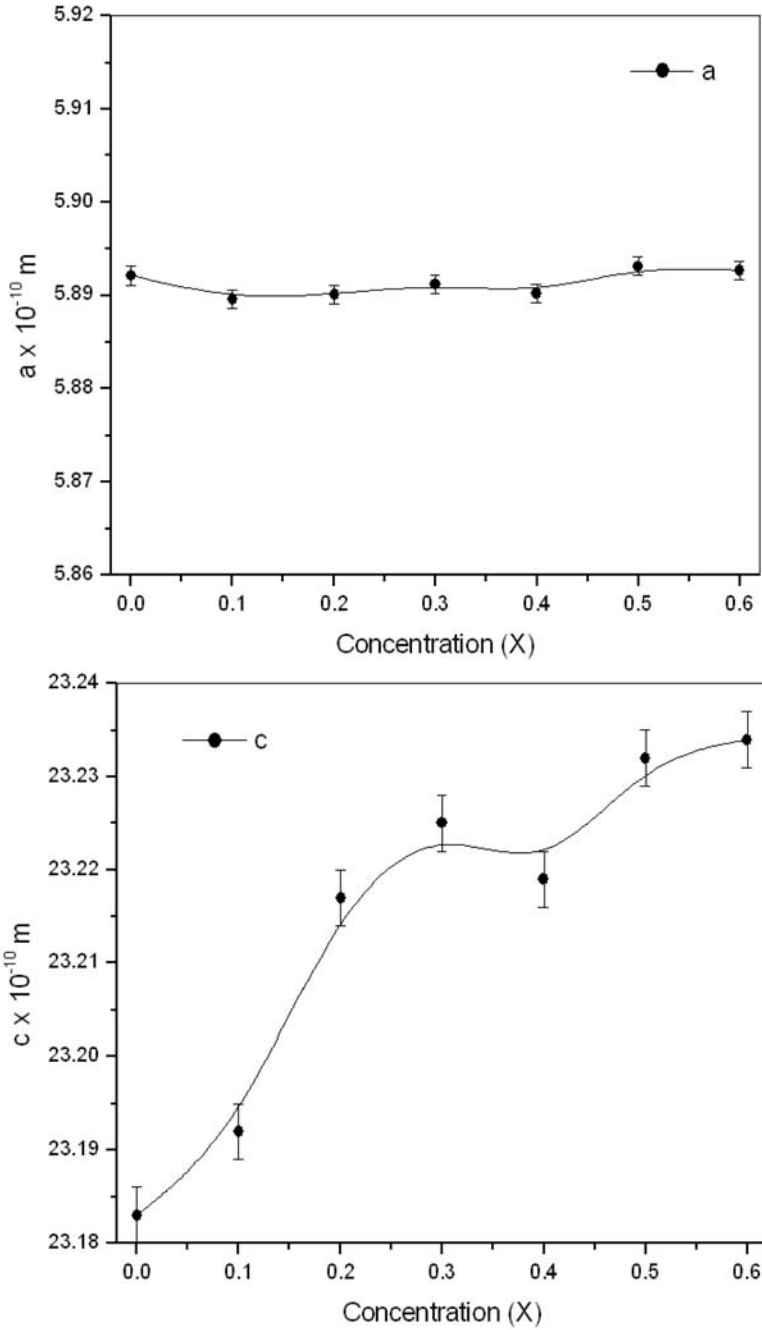
$$\frac{1}{d_{hkl}^2} = \frac{4}{3} \left( \frac{h^2 + hk + k^2}{a^2} \right) + \frac{l^2}{c^2} \quad (1)$$



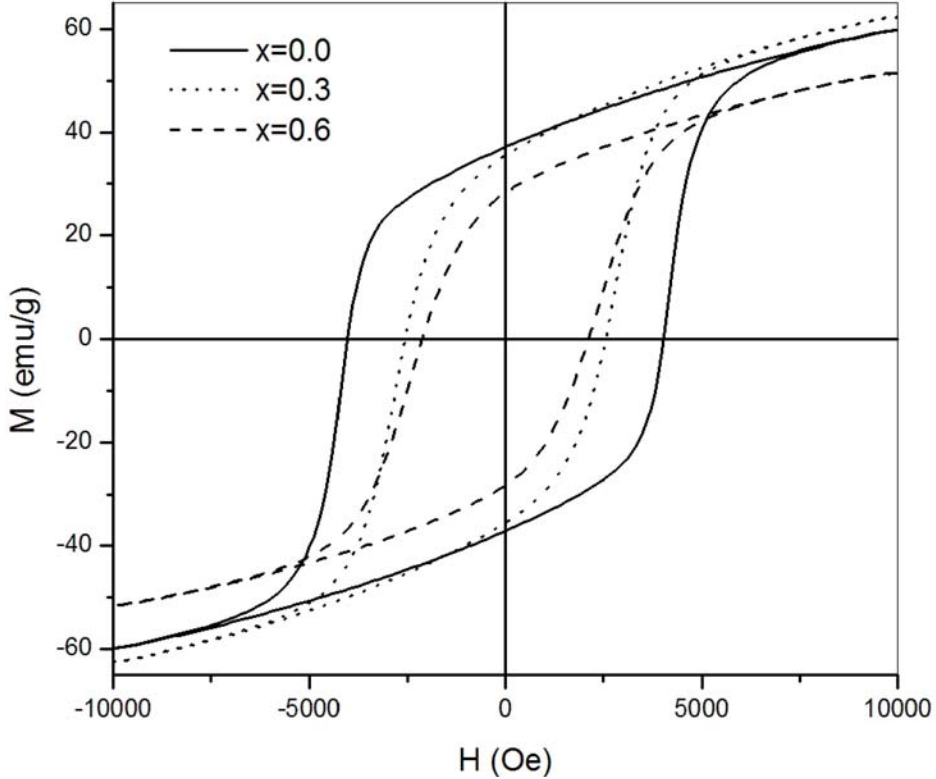
**Figure 1:** XRD patterns for some concentrations of  $BaFe_{12-x}Sb_xO_{19}$ .

The variation of hexagonal lattice parameters  $a$  and  $c$  with Sb content for all doping concentration examined in this work are presented in Fig. 2. Lattice constant  $a$  remains constant, whereas hexagonal lattice constant  $c$  increases with increasing Sb concentration. This indicates that the change of easy magnetized  $c$ -axis is larger than that of  $a$ -axis for the substitution with Sb. The increase of  $c$  might be a result of size effect, since the radius of  $Fe^{3+}$  ion, 0.645 Å, is smaller than that for  $Sb^{3+}$  ion, 0.76 Å. This change in lattice parameters might change the distance between magnetic ions, which leads to a disturbance in exchange interaction, thus magnetic properties can be alerted by the substitution.

Fig. 3 shows the measured hysteresis loops for some of the  $BaFe_{12-x}Sb_xO_{19}$  samples as a function of applied magnetic field. The magnetization curve for the non-substituted sample belongs to hard magnetic material with high coercive field strength of 4 kOe. This value of the coercivity agree with the previous works such as sol-gel method [17], mechanical alloying method [1] and ball milling method [21] of preparing barium ferrite.



**Figure 2:** Lattice parameters  $a$  and  $c$  of  $BaFe_{12-x}Sb_xO_{19}$  as a function of Sb concentration.



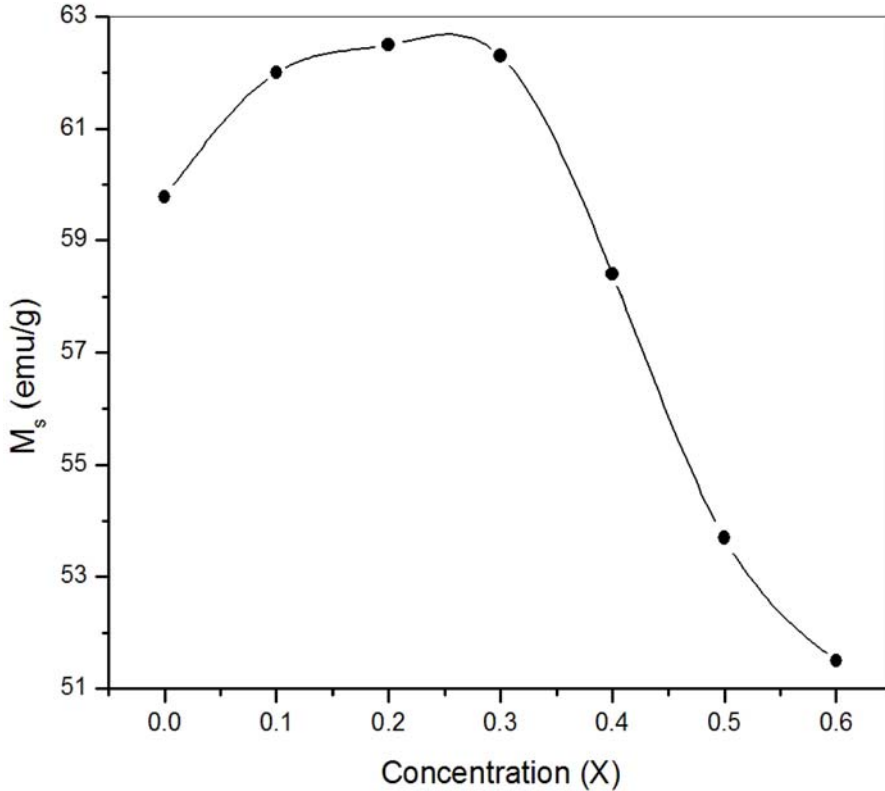
**Figure 3:** Hysteresis loops for some of the  $BaFe_{12-x}Sb_xO_{19}$  samples as a function of applied magnetic field.

The effect of Sb ions on the saturation magnetization of  $BaFe_{12-x}Sb_xO_{19}$  is shown in Fig. 4. The saturation magnetization increases with the increase of Sb concentration up to  $x=0.3$  recording 62.5 emu/g, while the saturation magnetization drops to 51.5 emu/g for  $x=0.6$ . The magnetic moment per formula for barium hexaferrite can be expressed according the following equation [22, 23]:

$$\bar{m} = \overline{2a} + \overline{2b} + \overline{12k} + \overline{4f_1} + \overline{4f_2} \quad (2)$$

The spin-down sites ( $4f_1$  and  $4f_2$ ) are occupied by two Fe ions each, whereas the spin-up sites  $2a$  and  $2b$  are occupied by one Fe ion each, and  $12k$  is occupied by six Fe ions [16]. Based on the above equation, the increase in the saturation magnetization in the concentration range  $x=0.1$  to  $x=0.3$ , can be attributed to the replacement of  $4f_1$  and  $4f_2$  spin-down  $Fe^{3+}$  ions by diamagnetic  $Sb^{3+}$  ions. The observed drop in the saturation magnetization in the concentration range  $x = 0.4 - 0.6$  might be associated with the replacement of  $Fe^{3+}$  ions by  $Sb^{3+}$  ions at the  $2a$  and  $2b$  spin-up sites, respectively. Furthermore, attenuation of the superexchange interaction between  $Fe^{3+}$  ions at  $2a$  and  $2b$  spin-up sites, might be occur as a result of the excessive replacement of the magnetic

ions by non-magnetic ones ( $\text{Sb}^{3+}$ ) in the concentration range  $x = 0.4 - 0.6$ , which is responsible for the drop in the saturation magnetization.



**Figure 4:** Saturation magnetization as a function of Sb concentration of barium ferrite samples.

Fig. 5 shows the coercive fields as a function of Sb concentration for all samples examined in this work. As one might observe the value of the coercivity for pure sample is 4000 Oe, which is in good agreement with the literature value, since the coercivity of pure  $\text{BaFe}_{12}\text{O}_{19}$  prepared by different methods is reported in the range (3000 – 5000) Oe [3, 24]. Also it is clear from these data that doping of barium ferrites with Sb leads to significant decrease in the coercivity as a result of the Sb substitution of  $\text{Fe}^{3+}$ . The reduction of the coercivity may be due to the decrease in the magnetic anisotropy field ( $H_a$ ) as a result of Sb substitution of  $\text{Fe}^{3+}$ .

Preparation and Investigation of the Magnetic Properties of Barium Hexaferrite Doped with Antimony

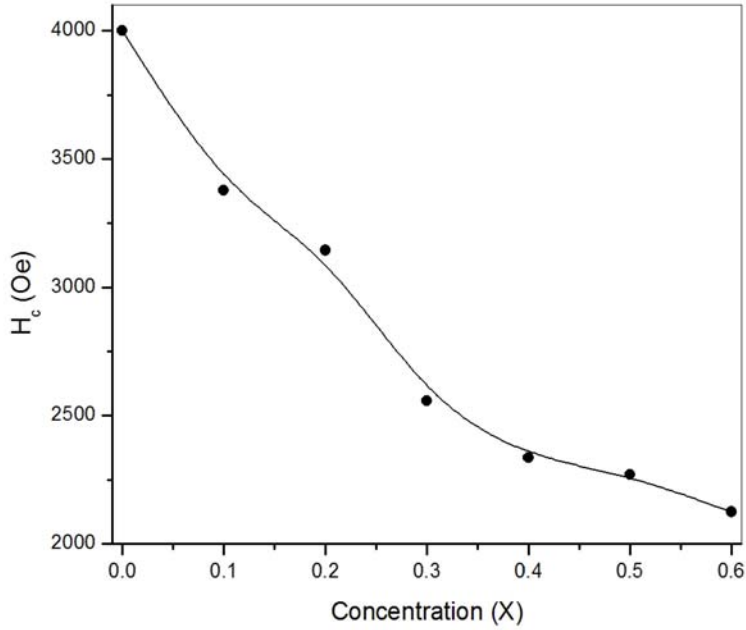


Figure 5: Coercive fields as a function of Sb concentration of barium ferrite samples.

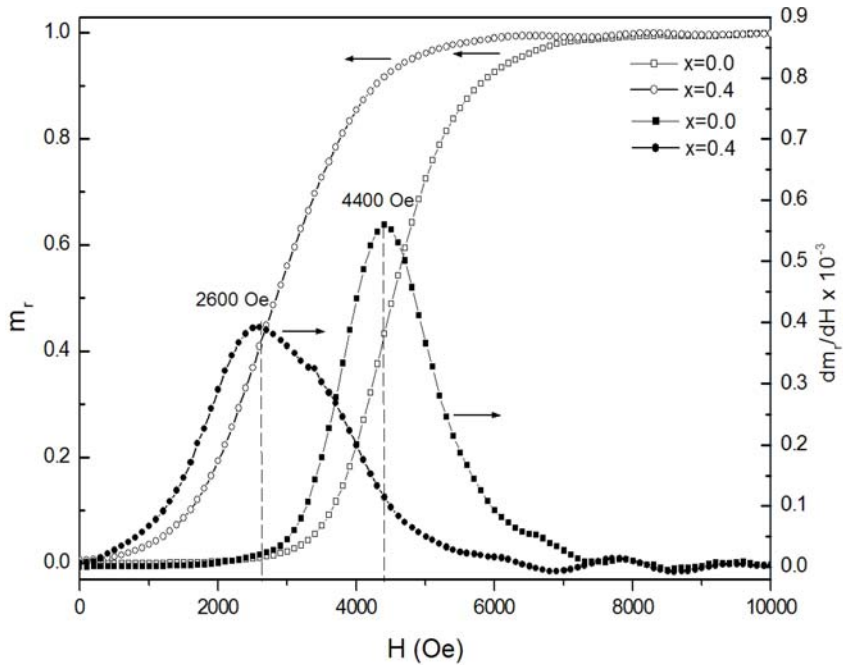
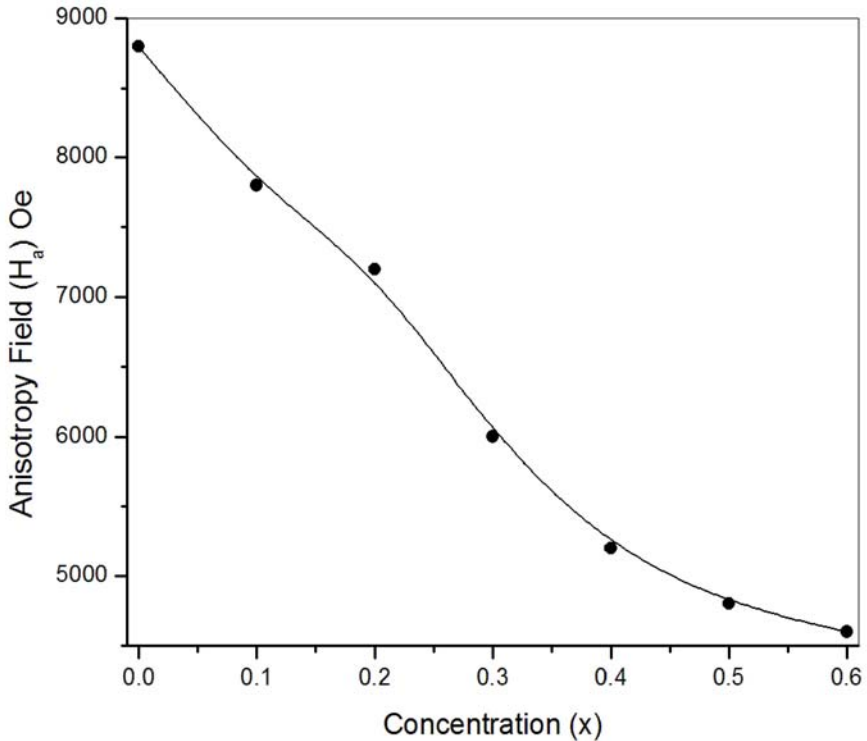


Figure 6: Reduced IRM curves and switching field distributions for the samples with  $x = 0.0$  and  $x = 0.4$ .

In order to investigate the correlation between the coercivity and the magnetic anisotropy field in our system, we determine the effective magnetic anisotropy field for each sample examined in this work from the switching field distribution (SFD). The switching field distribution can be obtained by differentiating the reduced isothermal remanent magnetization (IRM) curve  $m_r(H) = M_r(H)/M_r(\infty)$ . Fig. 6 shows the reduced IRM curve and the corresponding switching field distribution for the samples with  $x = 0.0$  and  $0.4$ . The effective magnetic anisotropy field for each sample examined in this work is obtained from the maximum of the switching field distribution according to the formula [25]:

$$f(H)_{\max} = \left[ \frac{dm_r}{dH} \right]_{H=H_a/2} \quad (3)$$

Here  $H_a = 2H_{\max}$ , where  $H_{\max}$  is the value of the field at the maximum of the SFD. Fig. 7 shows the variation of magnetic anisotropy field with Sb concentration for all samples examined. It is clear that  $H_a$  decreases monotonically with increasing Sb concentration up to  $x = 0.6$ , which might be the reason of suppressing the coercivity (Fig. 5). It could be noted that, the decrease in anisotropy field might leads to decrease in energy barriers, as a result a smaller field is required to reverse the magnetization, which suppress the coercivity.



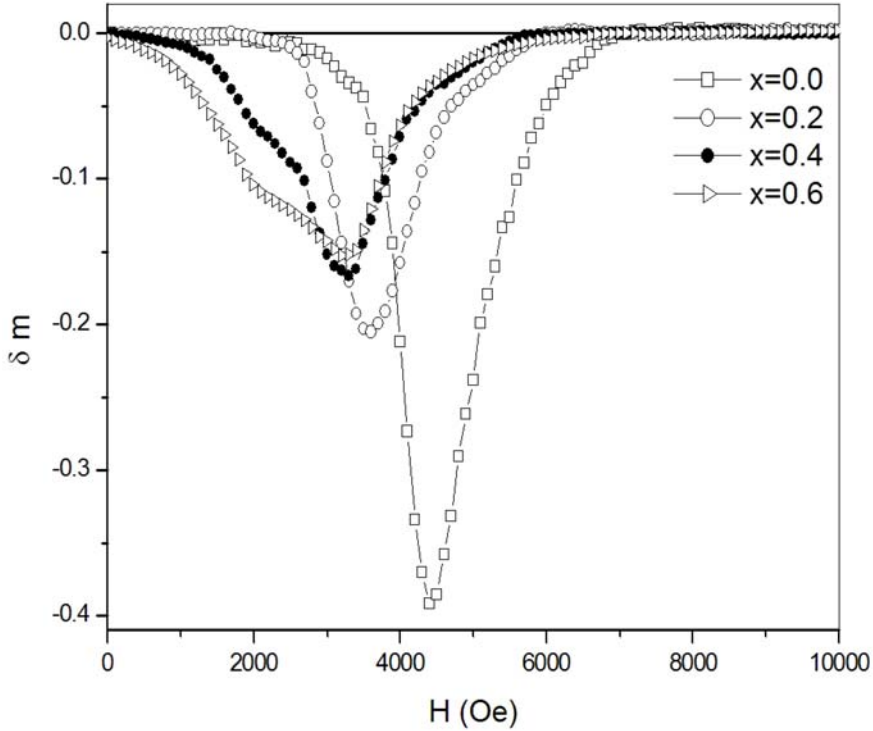
**Figure 7:** Anisotropy field as a function of Sb concentration of barium ferrite samples.

### Preparation and Investigation of the Magnetic Properties of Barium Hexaferrite Doped with Antimony

In order to investigate the role of doping with Sb on the interaction effects we use  $\delta m$  relationship given by Kelly [26]:

$$\delta m(H) = m_d(H) - [1 - 2m_r(H)] \quad (4)$$

where  $m_r(H)$  is the reduced isothermal remanent magnetization (IRM) and  $m_d(H)$  is the reduced dc demagnetization (DCD). The IRM curve was obtained by the following procedure: first the sample was demagnetized, second applying positive field, third measuring the remanence magnetization after removing the applied field. The procedure was repeated with increasing the positive field to reach positive saturation remanence. The DCD curve was obtained by, first, the sample was saturated with a positive field of 10 kOe, second a negative field was applied to the sample, third remanence magnetization was recorded after removing the negative field and at last this procedure was repeated with increasing the negative field until negative saturation remanence was reached.  $\delta m$  curves give the strength and the sign of the interaction in the prepared samples. For non interacting systems  $\delta m$  plots will show a horizontal line, any deviation from linearity in  $\delta m$  is a sign for the existence of interparticle interactions. Positive  $\delta m$  values indicates the existence of interparticle interactions that contribute constructively to the magnetization (magnetizing like effect), while negative  $\delta m$  values suggest that the existing interactions are demagnetizing (demagnetizing like effect), i.e. negative  $\delta m$  means interactions that assists the reversal mechanisms. Fig. 8 shows the  $\delta m$  plots for barium ferrite samples at different doping concentration of Sb. These curves show the magnitude of particle interaction in each sample. The curves show negative  $\delta m$  which according to equation (4) result from the interaction making it difficult to magnetize the sample from the demagnetized state (demagnetizing-like effect), or from  $m_d$  being easy to demagnetize. These data suggest that the interaction fields in these samples have a negative values and interaction effects decrease in magnitude with the increase of Sb concentration. Thus it seems that the particles tend to form clusters rather than a column of stacked platelets, i. e. the cluster growth in the doped samples seems to be less than for the pure one.



**Figure 8:**  $\delta m$  curves of  $BaFe_{12-x}Sb_xO_{19}$  for some of the concentration examined

## Conclusion

Our data suggest that doping of barium ferrite with Sb ( $BaFe_{12-x}Sb_xO_{19}$ ) leads to increase in  $c$  lattice parameter, and to significant reduction in the coercivity as a result of suppression of the anisotropy field. Also it was found that Sb doping enhances the saturation magnetization at low concentrations and reduces it for concentration higher than  $x=0.3$ . It was found that  $\delta m$  curves are negative for both pure and doped barium ferrite samples. Also it was found that  $\delta m$  value for the pure sample is more negative than for those doped with Sb, which suggests that doping with Sb reduce the process of clusters formation.

## تحضير ودراسة الخصائص المغناطيسية للباريوم فرايت

### السداسي المشاب بالانتيومون

#### ملخص

تم تحضير مركبات الباريوم فرايت السداسي المشاب بالانتيومون  $BaFe_{12-x}Sb_xO_{19}$  بقيم  $0 \leq x \leq 0.6$  بطريقة الطحن بالكرات. تبين من القياسات المغناطيسية ان قيمة مغنطة الاشباع تزداد مع زيادة نسبة الشوائب الى  $x=0.3$  بعد ذلك تنخفض قيمة مغنطة الاشباع في المدى من  $x=0.3$  الى  $x=0.6$ . بينما تبين ان المجال القسري يتناقص مع زيادة نسبة الانتيومون لكافة التراكيز التي تمت دراستها وتبين ان التناقص في المجال القسري مرده الى التناقص في مجال التباين الناتج عن عملية التشويب بالانتيومون. تبين من الدراسة ان منحنيات  $\delta m$  سالبة لجميع العينات المحضرة، مما يدل على وجود تفاعلات داخلية تساعد في عمليات عكس المغنطة. و قد تبين ايضا ان عملية الاشابة بالانتيومون تعمل على التقليل من شدة التفاعلات المساعدة في عملية عكس المغنطة و تكوين الكلسترات.

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# Long Memory Estimation of FIGARCH Model

Mahmoud Helan\* and Suleiman Tashstoush\*

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## Abstract

The aim of this study is to suggest a slightly different version of the parameters estimation of the Fractionally Integrated Generalized Autoregressive Conditional Heteroskedasticity (FIGARCH) since the parameterizations estimation method as reported by [2, 14] has some specification problems. A wide-range simulation is conducted to exhibit small sample properties of the estimation and to verify the declaration regarding the drawback of the old specification. The results of this study indicate that the long memory estimator of important parameters in the FIGARCH model may experience a lower convergence rates.

**Keywords:** Long memory, FIGARCH Process, Parameterization, Estimation, Simulation.

## 1. Introduction

It has been widely reported that volatility of many financial and macroeconomic time series is highly persistent. The seminal papers by [16, 13] led to the development of the long memory stochastic volatility models of [9, 22], and the long memory Autoregressive Conditional Heteroskedastic (ARCH) models of one simple approach to model persistent volatility, proposed by [2,14] denoted as (BBM/D'S), and is to incorporate the idea of long memory fractional differencing into the Generalized Autoregressive Conditional Heteroskedastic (GARCH) model. While these models appear useful in describing many empirical volatility processes, there is understandably great interest in discerning the reasons and underlying causes for the widespread empirical finding of long memory in volatility. In particular, Granger and [16] have shown that contemporaneous aggregation of stable GARCH(1,1) processes can result in an aggregate process that exhibits hyperbolically decaying autocorrelations. While this property appears to be consistent with long memory, [34] has shown that the autocorrelation function is assumable, which is inconsistent with it being classified as a long memory process. A related argument of [1] shows how the contemporaneous aggregation of weakly dependent information flow processes can produce the property of long memory in volatility. A further justification is provided by [29], who suggests that long memory in volatility can arise from the reaction of short-term dealers to the dynamics of a proxy for the expected volatility trend (coarse volatility), which causes persistence in the higher frequency volatility or (fine volatility) process.

A number of previous papers have observed and provided application of fractional integrated models in many fields, namely; stock returns [5, 6, 15, 31, 28, 26, 25, 32]; exchange rate [2, 14, 12] and inflation rate [3]. However, in the literature, up to this period, there have been little applications of the fractional integrated GARCH class models to commodity futures markets.

Baillie [4] examined long memory models in volatility properties of both daily and high frequency intraday futures for six important commodities. They found that the volatility processes were found to be very well described by FIGARCH models, with statistically significant long memory parameter estimates. Recently, [24] explored a long memory conditional volatility model on international grain markets; namely wheat, corn and soybeans, and compare the performance of the models in capturing dependence of the price volatility and also emphasized suitability of the student-*t* density intended to account for non-normal, fat-tailed properties of the data. [11] explored the relationship between basis long memory and hedging effectiveness measures with error-correction and the multivariate GARCH model.

After this introduction, the rest of the paper is organized as follows: in section 2 we dispute that there is a problem in BBM/D's parameterization of the FIGARCH model that causes difficulties in both estimation and the interpretation of the resulting estimates can be fixed with slightly different parameterization for which we offer a fairly thorough simulation analysis. Extensive simulation is then used in section 3 to appraise BBM/D's parameterization, to verify our assertion about its drawback, and to assess small sample properties of the Approximate Maximum Likelihood Estimation (AMLE). Conclusions are finally presented in section 4.

## 2. Long Memory and FIGARCH Model

The concept of long memory was introduced in time series analysis by [18, 23]. It is well known (e.g., [20] - p. 50) that, for stationary ARMA processes, the autocorrelation function decreases exponentially. By contrast, as suggested in the literature, one way of arguing that a process possesses long memory is that its autocorrelation function decreases "slowly". The most simple way to obtain long memory is to incorporate in the ordinary ARMA(p,q) formulation the fractional difference operator  $(1-B)^d$ , with  $0 \leq d \leq 1$ , where  $B$  denotes the backshift operator. The resulting process is known as AutoRegressive Fractionally Integrated Moving Average, (ARFIMA), (see, [3]).

A stochastic process  $y_t$  is said to follow fractionally integrated ARMA process of orders  $p$  and  $q$ , or ARFIMA( $p, d, q$ ) process, if it is defined by

$$\phi(B)(1-B)^d(Y_t - \mu) = \theta(B)a_t \tag{1}$$

where, as in the standard ARMA model,  $\mu$  is the unconditional mean of  $y_t$ , while the

autoregressive operator  $\phi(B) = 1 - \sum_{j=1}^p \phi_j(B^j)$  and the moving-average operator

$\theta(B) = 1 + \sum_{j=1}^q \theta_j(B^j)$  are polynomials of order  $p$  and  $q$ , respectively, in the lag operator  $B$ , and the innovations  $a_t$  are white noises with variance  $\sigma^2$ . The usual stationarity and invertability conditions for the ARMA model are assumed. It is the fractional differencing operator  $(1-B)^d$  with  $d$  being a fraction number  $0 < d < 1$  that allows the process  $y_t$  to have the long memory property. The fractional differencing operator is in fact a notation for the following infinite polynomial:

$$(1-B)^d = \sum_{j=0}^{\infty} \frac{\Gamma(j-d)}{\Gamma(j+1)\Gamma(-d)} B^j \equiv \sum_{j=0}^{\infty} \pi_j(d) B^j \quad (2)$$

Where  $\Gamma(\cdot)$  is the standard gamma function. To ensure stationary and invariability of the process  $y_t$  we assume that  $d$  lies between 0 and 0.5, [3].

Given the conditional variance  $h_t = Var(a_t / s_{t-1})$  where  $s_{t-1}$  represents the information set up to the time period  $t-1$ , the GARCH model for  $h_t$  is

$$h_t = \sigma^2(1 - \alpha(B) - \beta(B)) + \alpha(B)a_t^2 + \beta(B)h_t \quad (3)$$

Where  $\sigma^2$  is the unconditional variance of  $a_t$  and  $\alpha(B) = \sum_{j=1}^p \alpha_j(B^j)$ ,  $\beta(B) = \sum_{j=1}^q \beta_j(B^j)$  are again polynomials in  $B$  of order  $q$  and  $p$ , respectively.

Such a GARCH( $p, q$ ) process can be rewritten conveniently as a model for:

$$(1 - \alpha(B) - \beta(B))a_t^2 = \omega + (1 - \beta(B))r_t \quad (4)$$

where  $r_t = a_t^2 - h_t$  can be viewed as innovations since they have zero mean and are serially uncorrelated, [3]. Here we assume that all the roots of the polynomials  $1 - \alpha(B) - \beta(B)$  and  $1 - \beta(B)$  lie outside the unit circle so that the  $a_t^2$  process is stationary. BBM/D'S propose the fractionally integrated GARCH or the FIGARCH model that generalizes the GARCH model (4) by replacing  $1 - \alpha(B) - \beta(B)$  by a polynomial that contains a fractional differencing term as follows

$$\alpha(B)(1-B)^d a_t^2 = \omega + (1 - \beta(B))r_t \quad (5)$$

where  $\alpha(B) = 1 - \sum_{j=1}^p \alpha_j(B^j)$

The definition of the fractional differencing operator  $(1 - B)^d$  is completely parallel to (2) but the exponent  $d$  is assumed to lie between 0 and 1. Equation (5) above is referred to as the FIGARCH( $p, d, q$ ) model by BBM/D'S. The corresponding conditional variance  $h_t$  can be expressed more explicitly as

$$(1 - \beta(B))h_t = \omega + ((1 - \beta(B))a_t^2 - (1 - B)^d)a_t^2 \quad (6)$$

It is interesting to note that the constant term  $\omega$  in the above FIGARCH specification (5) is structurally different from  $\mu$  in the ARFIMA model (1): the fractional differencing operator  $((1 - B)^d)$  applies to  $\mu$  while  $(1 - B)^d$  does not apply to  $\omega$ . However, it is easy to avoid such discrepancy in parameterization: we simply rewrite the GARCH( $p, q$ ) model (4) as follows

$$(1 - \alpha(B) - \beta(B))(a_t^2 - \sigma^2) = (1 - \beta(B))r_t \quad (7)$$

and then redefine the FIGARCH model as:

$$\alpha(B)(1 - B)^d (a_t^2 - \sigma^2) = (1 - \beta(B))r_t \quad (8)$$

We note that [9] have also briefly considered this particular parameterization. Obviously, the relationship between the  $\omega$  parameter in BBM/D'S specification (5) and the  $\sigma^2$  parameter is

$$\omega = \alpha(B)(1 - B)^d \sigma^2 \quad (9)$$

Here we only note that the conditional variances  $h_t$  implied by the FIGARCH model (8) can be expressed more explicitly as follows:

$$(1 - \beta(B))h_t = (1 - \beta(B))a_t^2 - \alpha(B)(1 - B)^d (a_t^2 - \sigma^2) \quad (10)$$

There are still three structural differences between the ARFIMA model (1) for the conditional mean  $\mu$  and the FIGARCH model (8) for the conditional variance  $h_t$ . First, we note that the ARFIMA( $a, 0, m$ ) model reduces to the ARMA( $a, m$ ) model but the FIGARCH( $p, 0, q$ ) model is not exactly the GARCH( $p, q$ ) model. Secondly, by extending the analysis of the Integrated GARCH models e.g., [30, 8], BBM/D'S have argued that the FIGARCH model, which is not weakly stationary, can be strictly stationary and ergodic for  $0 < d < 1$ . Hence, the ranges of fractional exponents  $d$  are different, and  $d$  is permitted to be greater than 0.5, which implies the degree of persistence allowed in conditional variances is larger than that in conditional means. Finally, while there is no sign restriction on the ARFIMA model for the conditional mean, the parameters of the FIGARCH model must be subject to additional restrictions to ensure that the resulting conditional variances be all non-negative. [6] have presented a set of sufficient conditions for non-negative conditional variances.

The most straightforward estimation method for the complicated ARFIMA-FIGARCH model is the approximate maximum likelihood estimation AMLE. Given that  $\{y_1, y_2, \dots, y_T\}$  is a realization the ARFIMA-FIGARCH model defined by (1) and (5), if we further assume that the innovations  $a_t$  are normally distributed, then the approximate log-likelihood function is defined as:

$$\ln L(\lambda) = -\frac{T}{2} \ln(2\pi) - 0.5 \sum_{t=1}^T \left[ \ln(h_t) - \frac{a_t^2}{h_t} \right] \quad (11)$$

where  $\lambda$  is the vector containing all parameters (By extending the results from [17], we have worked out the analytic expressions for partial derivatives of the  $\ln L(\lambda)$  which can be made available upon request). The asymptotic theory for estimation of the FIGARCH model is less complete than that of the ARFIMA model. It seems that for the general FIGARCH model, the asymptotic theory for the AMLE can only be assessed through simulation at the present stage. Here we only extend the results of the ARFIMA and the Integrated (IGARCH(1,1)) models as BBM/D'S did and claim that the AMLE of  $\lambda$  is consistent and converges at the  $\sqrt{T}$  rate to a normal distribution.

The computations of the approximate log-likelihood function (11) (and its first-order derivatives) require the values of innovations  $a_t$  and the conditional variances  $h_t$ , but it is  $y_t$  that we observe. So before implementing the AMLE, we need to transform  $y_t$  to  $a_t$  and  $h_t$  based on (1) and (8). With given values of parameter vector  $\lambda$ , we first calculate  $a_t$ , for  $t = 1, 2, \dots, T$ , in two steps where we introduce notation  $\zeta_t$  for the intermediate result:

Step 1 find

$$\xi_t = \sum_{j=0}^{t-1} \pi_j(d)(y_{t-j} - \mu), \text{ and } \varepsilon_t = \xi_t - \sum_{j=1}^m \phi_j \xi_{t-1} - \sum_{j=1}^m \theta_j \varepsilon_{t-j}$$

Once obtain the values of  $\varepsilon_1, \varepsilon_2, \dots, \varepsilon_T$ , we can compute the conditional variances  $h_t$  for  $t=1, 2, \dots, T$ , based on (10) again in the above step in which the intermediate result is denoted as  $\zeta_t$  :

Step 2: find

$$\zeta_t = \sum_{j=0}^{t-1} \pi_j(d)(\varepsilon_{t-j}^2 - \sigma^2) ; h_t = \sum_{j=1}^p \beta_j h_{t-j} = \sum_{j=1}^p \beta_j \varepsilon_{t-j}^2 + \varepsilon_t^2 - \zeta_t \sum_{j=1}^q \varphi_j \zeta_{t-j}$$

As in numerous applications of the AMLE estimation to the ARMA-GARCH model, the pre-sample values of  $\xi_t$  and  $\varepsilon_t$ , for  $t = 0, -1, -2, \dots$ , involved in Step 1 are all set to 0, while the pre-sample values of  $\varepsilon_t^2$  and  $h_t$ , for  $t = 0, -1, -2, \dots$ , involved in Step 2 are all set to  $\hat{\sigma}^2 \equiv T^{-1} \sum_{t=1}^T \varepsilon_t^2$ . More importantly, the pre-sample values of  $(y_t - \mu)$  and  $(\varepsilon_t^2 - \sigma^2)$  in computing fractional differencing in Steps 1 and 2 have all been replaced by 0 (so that the summation runs from 0 to  $t - 1$  instead of  $\infty$ ). This choice of the pre-sample values may be an issue of concerns. To see more clearly what the problem might be, we note for example that in step 1 the exact relationship between  $\xi_1$  and  $y_1$  should be

$$\xi_1 = (y_1 - \mu) + \pi_1(d)(y_0 - \mu) + \pi_2(d)(y_{-1} - \mu) + \dots$$

But the value of  $\xi_1$  computed from Step 1 is simply  $(y_1 - \mu)$  and the remaining terms are all truncated. Similarly, the calculations of  $\xi_2, \xi_3, \dots$  all involve various degrees of “truncation errors.” It is certainly worrisome that these zero pre-sample values may leave too large errors to the log-likelihood function and thus bias the resulting parameter estimates, especially when sample size is small. However, the simulation studies for the ARFIMA model by [10] find that even with sample size as small as 300, using the AMLE causes relatively little bias as long as the value of the parameter  $d$  is not too close to 0.5. A possible reason for this result is that given  $\mu = E(y_t)$ , we can expect  $(y_t - \mu)$  to be small in absolute values and have a zero average so that assuming the zero pre-sample values for  $(y_t - \mu)$  may not be too unreasonable. Now, given that  $\sigma^2 = E(\varepsilon_t^2)$ , it is for the same reason we believe that the differences  $(\varepsilon_t^2 - \sigma^2)$  are also small in absolute values and have a zero average. Therefore, we propose to set the pre-sample values of  $(\varepsilon_t^2 - \sigma^2)$  to zero in Step 2.

### 3. Simulation Results

Our simulation study is divided into two parts. In the first part we demonstrate the problem in estimating the  $\omega$  parameter of BBM/D'S formulation (5) of the FIGARCH model and in the second part we assess small-sample properties of the AMLE for the proposed specification (8). In all simulation experiments the data-generation and estimation processes are repeated 400 times. From the 400 sets of parameter estimates we compute the averages and then define the differences between these averages and corresponding true parameter values as “biases.” The square root of the sample variance of the 400 simulation results are referred to as “SE.” In each simulation trial, asymptotic standard errors (ASE) are also computed based on the inverse of the second-order derivative of the approximate log-likelihood function (11) as well as the robust formula

due to [33, 7], and their averages are referred to as “MASE1” and “MASE2,” respectively. All computation is conducted using the **Ox package (G@RCH 2.3)**.

### 3.1 Estimating the parameter $\omega$

We first present simulation results to illustrate the problem in estimating the  $\omega$  parameter of BBM/D'S formulation (5) of the FIGARCH model. There the data are generated according to BBM/D'S specification of the simplest ARFIMA(0, 0, 0)-FIGARCH(0,  $d$ , 0) model. The data are then used to estimate BBM/D'S specification. Nine values of  $d$  are considered while the value of  $\omega$  is set to 1 when data are simulated even though such a value is not theoretically plausible. The sample size is fixed at 1,000. The most important part of the experiment design is that we try three different truncation levels:  $N = 100, 500,$  and  $1,000$ . Column three of Table (1) shows the averages of the  $\omega$  estimates where the inverse relationship between the  $\omega$  estimates and  $N$  is strikingly obvious. Moreover, it seems that setting  $N$  to the small value of 100 in the present model specification produces the least biases. But this observation completely contradicts to the belief that  $N$  should be made as large as possible in order to minimize the truncation error. As to the SE and MASE results, we note that the  $\omega$  estimates follow the standard asymptotic theory for AMLE.

**Table 1** : Simulation Results for BBM/D's FIGARCH(0,d,0) Model for Estimating  $\omega$

| d   | MEANS |       |        | SE    |       |        | MASE  |       |       |
|-----|-------|-------|--------|-------|-------|--------|-------|-------|-------|
|     | N=100 | N=500 | N=1000 | N=100 | N=500 | N=1000 | N=100 | N=500 | N=100 |
| 0.1 | 1.100 | 1.052 | 1.008  | 0.218 | 0.236 | 0.233  | 0.224 | 0.235 | 0.239 |
| 0.2 | 1.051 | 0.961 | 0.901  | 0.218 | 0.216 | 0.201  | 0.225 | 0.216 | 0.210 |
| 0.3 | 0.981 | 0.932 | 0.801  | 0.189 | 0.185 | 0.171  | 0.223 | 0.229 | 0.225 |
| 0.4 | 0.941 | 0.795 | 0.712  | 0.255 | 0.253 | 0.256  | 0.281 | 0.316 | 0.339 |
| 0.5 | 0.952 | 0.851 | 0.784  | 0.298 | 0.332 | 0.338  | 0.321 | 0.348 | 0.368 |
| 0.6 | 0.998 | 0.932 | 0.863  | 0.289 | 0.298 | 0.316  | 0.284 | 0.351 | 0.319 |
| 0.7 | 1.006 | 0.981 | 0.978  | 0.209 | 0.236 | 0.234  | 0.217 | 0.224 | 0.242 |
| 0.8 | 1.021 | 0.999 | 0.980  | 0.168 | 0.156 | 0.169  | 0.167 | 0.168 | 0.171 |
| 0.9 | 1.003 | 0.999 | 0.991  | 0.122 | 0.123 | 0.124  | 0.121 | 0.123 | 0.125 |

In Table (2) we go one step further to examine what problem may arise if data are generated according to our specification (8) while BBM/D'S formulation (5) is used for estimation. Here, for all experiments, the sample size is fixed at 1,000 and three truncation levels  $N = 100, 500, 1,000$  are tried.

We should note that the data generating process is not based on any specific value of  $\omega$  (while we may argue the “true” value of  $\omega$  is zero). So it is not surprising that the estimates of  $\omega$  vary widely. The inverse relationship between the  $\omega$  estimates and  $N$  appears again just like in Table 1. We also note that both the biases and the differences between SE and MASE for  $d$  increase sharply as  $d$  passes 0.5 from below. We do not observe such changes in Table 1 where the data are generated from BBM/D, S formulation.

**Table 2 :** Simulation Results for BBM/D's FIGARCH(0,d,0) Model for Estimating  $\omega$

| d   | MEANS |       |        | SE    |       |        | MASE  |       |        |
|-----|-------|-------|--------|-------|-------|--------|-------|-------|--------|
|     | N=100 | N=500 | N=1000 | N=100 | N=500 | N=1000 | N=100 | N=500 | N=1000 |
| 0.1 | 0.548 | 0.511 | 0.493  | 0.113 | 0.112 | 0.114  | 0.118 | 0.117 | 0.119  |
| 0.2 | 0.269 | 0.244 | 0.221  | 0.059 | 0.062 | 0.056  | 0.062 | 0.060 | 0.058  |
| 0.3 | 0.136 | 0.113 | 0.104  | 0.032 | 0.029 | 0.027  | 0.033 | 0.032 | 0.034  |
| 0.4 | 0.072 | 0.058 | 0.052  | 0.028 | 0.024 | 0.021  | 0.025 | 0.024 | 0.026  |
| 0.5 | 0.032 | 0.026 | 0.024  | 0.017 | 0.014 | 0.016  | 0.014 | 0.015 | 0.016  |
| 0.6 | 0.013 | 0.011 | 0.010  | 0.007 | 0.006 | 0.006  | 0.005 | 0.005 | 0.006  |
| 0.7 | 0.003 | 0.003 | 0.003  | 0.002 | 0.002 | 0.001  | 0.001 | 0.001 | 0.001  |
| 0.8 | 0.001 | 0.001 | 0.001  | 0.001 | 0.000 | 0.000  | 0.000 | 0.000 | 0.000  |
| 0.9 | 0.000 | 0.000 | 0.000  | 0.000 | 0.000 | 0.000  | 0.000 | 0.000 | 0.000  |

### 3.2 Estimating the parameter $\sigma^2$

Let's now turn to the second part of our simulation study to demonstrate the small sample properties of the estimation based on the proposed formulation (8). We present in Table 3 the simulation results for  $\sigma^2$  and the fractional differencing parameter  $d$  in the simplest ARFIMA(0, 0, 0)-FIGARCH(0,  $d$ , 0) model. We try three different realization sizes  $T = 250, 500, \text{ and } 1,000$  and  $d = 0.1 (0.1) 0.9$ . The true value of  $\sigma^2$  is set at 1. The simulation results in Table (3) clearly demonstrate that the estimates of the fractional differencing parameter  $d$  do follow the pattern suggested by the standard asymptotic theory for the AMLE: The SE are of the same magnitude of the two MASE (and all of them exhibit an interesting inverted U-shape pattern as  $d$  increases) and the speeds at which SE decline as the sample size  $T$  increases from 250 to 500 and from 500 to 1,000 are approximately the  $\sqrt{T}$  rates. Moreover, we find that SE, and two MASE here are all less than their counterparts in Tables (1) and (2) (with  $T = 1, 000$ ). In other words, for the purpose of efficient estimation of  $d$ , our specification (8) does a better job than BBM/Ds formulation (5).

**Table 3:** Simulation Results for ARFIMA(0,0,0) – FIGARCH(0,d,0) Model for Estimating  $\sigma^2$

| D   | MEANS |       |        | SE    |       |        | MASE  |       |        |
|-----|-------|-------|--------|-------|-------|--------|-------|-------|--------|
|     | N=250 | N=500 | N=1000 | N=250 | N=500 | N=1000 | N=250 | N=500 | N=1000 |
| 0.1 | 0.002 | 0.001 | 0.000  | 0.152 | 0.106 | 0.091  | 0.147 | 0.115 | 0.088  |
| 0.2 | 0.039 | 0.030 | 0.025  | 0.321 | 0.022 | 0.187  | 0.296 | 0.236 | 0.186  |
| 0.3 | 0.138 | 0.101 | 0.045  | 0.586 | 0.452 | 0.345  | 0.524 | 0.415 | 0.361  |
| 0.4 | 0.238 | 0.211 | 0.143  | 0.867 | 0.744 | 0.562  | 0.726 | 0.614 | 0.492  |
| 0.5 | 0.461 | 0.274 | 0.259  | 1.465 | 0.981 | 0.701  | 1.009 | 0.802 | 0.621  |
| 0.6 | 0.621 | 0.425 | 0.321  | 1.736 | 1.046 | 0.921  | 1.236 | 0.996 | 0.721  |
| 0.7 | 0.598 | 0.321 | 0.241  | 1.891 | 1.006 | 0.710  | 1.432 | 0.901 | 0.651  |
| 0.8 | 0.499 | 0.321 | 0.150  | 1.575 | 0.925 | 0.589  | 1.311 | 0.961 | 0.563  |
| 0.9 | 0.539 | 0.321 | 0.124  | 1.765 | 1.087 | 0.636  | 1.396 | 0.965 | 0.602  |

In contrast, the simulation results for  $\sigma^2$  present a quite different picture. The small-sample biases are considerably large and almost always positive, especially when  $d$  is greater than 0.2, which is in sharp contrast to the earlier results on the  $\omega$  estimates in Table (1). We also notice that the disagreement between SE and the two MASE can be quite serious when  $d$  is greater than 0.2. So it is not surprising to find that the AMLE of  $\sigma^2$  also shows certain abnormality. Inspecting the general pattern of SE and MASE corresponding to the three sample sizes shown in Table 3 we notice that the convergence rate of the  $\sigma^2$  estimate appears getting slower as  $d$  ascends from 0.1 to 0.3 but then turns around and becomes increasingly faster as  $d$  approaches 0.9. These simulation results, however, are too inconclusive to indicate what the changing convergence rates really are. But they certainly raise the question about the applicability of the standard asymptotic theory to the  $\sigma^2$  estimator. In spite of the unsettled discussion regarding the  $\sigma^2$  estimates, we nevertheless obtain a valuable and quite encouraging result that the substantial biases and irregular convergence rates in the  $\sigma^2$  estimates do not adversely affect the estimation of  $d$  (and all other parameters in the ARFIMA-FIGARCH model as will be seen shortly) at least in cases where  $d$  is smaller than 0.3. We thus draw a conclusion that the FIGARCH model appears to be a feasible generalization of the GARCH model (perhaps with the qualification that  $d$  lies between 0 and 0.3, instead of 1.

#### 4. Conclusions

In this paper we consider the long memory FIGARCH model for the conditional variance. In our analysis we quarrel that [2] parameterization of the FIGARCH model may have a specification problem. The results are obtained by using approximate maximum likelihood estimation (AMLE) provided by [27] in Ox package (G@RCH 2.3). Our simulation results reveal that the estimation may experience difficulties similar to those in estimating unconditional mean of the more familiar fractionally integrated ARMA (ARFIMA) process. It is well-known that the estimator of the unconditional mean in the ARFIMA model has non-standard asymptotic behavior, our simulation results hint that the estimator of an important parameter in the FIGARCH model may have similar non-standard properties with slower convergence rates. Aside from this important observation, our simulation results confirm that the FIGARCH model is a viable generalization of the conventional GARCH model that allows us to model and estimate persistent conditional variances. Specifically, we have obtained clear simulation results showing that the estimates of  $\omega$  are inversely related to the level of truncation when fractional differencing is calculated. Our simulation study also demonstrates small sample properties of the estimation for the new specification. We obtain the fairly encouraging results that, except, the estimators of FIGARCH parameters seem to follow the standard asymptotic theory for the MLE. However, simulation results also indicate that the estimator of  $\sigma^2$  in the FIGARCH model may experience lower convergence rates, a phenomenon that is similar to what we knew about the estimator of the unconditional mean  $\mu$  in the ARFIMA model. Moreover, the permissible range of the

fractional differencing parameter  $d$  in the FIGARCH model may be much narrower than what has been suggested in the literature. In this regard, we have to point out that simulation cannot provide sufficient evidence to pin down the exact range for  $d$  and this issue certainly calls for further studies.

## التقدير باستخدام الذاكرة الطويلة لمعاملات نموذج FIGARCH

محمود حيلن وسليمان طشطوش

### ملخص

تهدف هذه الدراسة الى اقتراح اسلوب مختلف نوعاً ما في تقدير المعلمات لنموذج FIGARCH لأن الاسلوب المعتاد كما ورد ع[2, 14] له بعض المشاكل المحددة. تم استخدام اسلوب محاكاة واسعة المدى لابرار خصائص العينات الصغيرة لهذا التقدير وللتأكد من أن المشاكل المحددة القديمة في اساليب التقدير تمت معالجتها. تشير نتائج هذه الدراسة الى أن التقدير باستخدام الذاكرة الطويلة للمعاملات المهمة في نموذج FIGARCH يمكن أن تصادف معدلات تلاقي ذات قيمة مقبولة.

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# On the Continuity and Fixed Point Theorem in the PN-Space

Rateb Al-Btoush\*, M.H.M. Rashid\* and Basem S. Masaedeh\*

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## Abstract

The aim of this paper is to introduce the concept of neighborhoods in PN-spaces and study some properties related to this concept. Also we will reconsider the topological structure of Menger probabilistic normed spaces (briefly PN-spaces) under the t-norm  $T$ . We shall give some examples to show that it is possible to construct complete PN-space together with contraction mappings which have no fixed point.

**Keywords:** Menger PN-space, Neighborhoods, Probabilistic metric space, Normed linear space, Distribution function, Triangle function, Serstnev space, Fixed point.

**2000 Mathematics Subject Classification:** 54E30, 54E35, 54E70, 54E50

## Introduction

The notion of a probabilistic metric space was first introduced by K. Menger in [9]. In this theory, the concept of the distance between two points has a probabilistic nature, i.e., it is exhibited by distribution functions. This theory was extended later to probabilistic normed linear spaces by Serstnev [11] and generalized by several other authors (see [1,2,3-11,14]). In this paper, we will consider a Menger probabilistic normed space under the t-norm  $T$ , and will obtain some results on its derived topology.

The results presented in this paper generalize and improve many results of S.S.Chang [4], and K.Menger [8-10], and many others in normed spaces and probabilistic normed spaces. The next definitions give a brief description for the background on which the paper will be built on.

**Definition 1.1**([4]) Let  $R$  denote the set of real numbers and  $R^+$  the non-negative reals. A mapping  $f : R \rightarrow R^+$  is called a distribution function if it is increasing and left continuous with  $\inf f = 0$  and  $\sup f = 1$ .

**Notation.** We will denote the set of all distribution functions by  $D$ .

**Definition1.2** ([8]) A probabilistically normed space (briefly a PN-space) is an ordered pair  $(X, f)$ , where  $X$  is a real line space and  $f$  is a mapping of  $X$  into  $D$ , satisfying the following conditions:

(PN-1)  $f_x(t) = 1$  for all  $t > 0$  if and only if  $x = 0$ .

(PN-2)  $f_x(0) = 0$ .

(PN-3)  $f_{\alpha x}(t) = f_x\left(\frac{t}{|\alpha|}\right)$  for all  $\alpha \in R, \alpha \neq 0$ .

(PN-4) If  $f_x(t_1) = 1$  and  $f_y(t_2) = 1$ , then  $f_{x+y}(t_1 + t_2) = 1$ .

Here  $f_x$  denotes the distribution function associated with  $x$ .

Recall that a  $t$ -norm is a binary operation on  $[0,1]$  that is commutative, associative, nondecreasing in each variable, and has 1 as identity. Dually, a  $t$ -conorm is a binary operation on  $[0,1]$  that is commutative, associative, nonincreasing in each variable, and has 0 as identity. If  $T$  is a  $t$ -norm, it's associated a  $t$ -conorm  $T^*$  is defined by  $T^*(x, y) := 1 - T(1 - x, 1 - y)$ . Given a  $t$ -norm  $T$  one defines the functions  $\tau_T$  and  $\tau_{T^*}$  respectively by

$$\tau_T(F, G)(x) := \sup\{T(F(s).G(t)) : s + t = x\},$$

and

$$\tau_{T^*}(F, G)(x) := \inf\{T^*(F(s).G(t)) : s + t = x\}.$$

Recall that if  $T$  is left-continuous, then  $\tau_T$  is a triangle function [6, p.100], although this is not necessary; for example, if  $Z$  denotes the minimum  $t$ -norm, defined as  $Z(1, x) = x$  and  $Z(x, y) = 0$  elsewhere, then  $\tau_Z$  is a triangle function which is not left continuous.

**Definition1.3** ([6]) A triangle inequality is said to hold universally in PN-space if it holds for all triples of points, distinct or not, in the space.

Let  $T : [0,1] \times [0,1] \rightarrow [0,1]$  be a 2-place function satisfying the following conditions:

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$$(T_1) \quad 0 \leq T(x, y) \leq 1.$$

$$(T_2) \quad T(a, b) \geq T(c, d) \text{ for } c \geq a, d \geq b.$$

$$(T_3) \quad T(a, b) = T(b, a).$$

$$(T_4) \quad T(1, 1) = 1.$$

$$(T_5) \quad T(a, 1) > 0 \text{ for } a > 0.$$

**Definition 1.4** ([9]) A Menger PN-space is a triple  $(X, f, T)$ , where  $(X, f)$  is a PN-space and  $T$  is a  $t$ -norm satisfying the following condition:

$$(PN - 4) \quad f_{x+y}(t_1+t_2) \geq T(f_x(t_1), f_y(t_2)) \text{ for all } x, y \in X \text{ and } t_1, t_2 \in R^+.$$

**Definition 1.5** ([5]) A Serstnev PN space is a PN space  $(V, f, \tau, \tau^*)$  where  $f$  satisfies the following Serstnev condition:

$$(S) \quad f_{\lambda p}(x) = f_p\left(\frac{x}{|\lambda|}\right), \text{ for all } x \in R^+, p \in V \text{ and } \lambda \in R \setminus \{0\}.$$

It turns out that (S) is equivalent to having  $f_{-p} = f_p$  and

$$f_p = \tau_M(f_{\lambda p}, f_{(1-\lambda)p}),$$

for all  $p \in V$  and  $\lambda \in [0, 1]$  (see [10, Theorem 1]), where  $M$  is the  $t$ -norm defined as

$$M(x, y) = \min\{x, y\}.$$

**Main Results.**

Our goal of this work is to introduce the concept of neighborhoods in PN-space and study some properties related to this concept.

**Definition 2.1** ([7]) Let  $p$  be a point in PN-space  $(X, f)$ . By an  $(\varepsilon, \lambda)$ -neighborhood (shortly nbd) of  $p, \varepsilon > 0, \lambda > 0$ , we mean the set of all points  $q$  in  $X$  for which

$$f_{p-q}(\varepsilon) > 1 - \lambda. \text{ We write}$$

$$N_p(\varepsilon, \lambda) = \{q : f_{p-q}(\varepsilon) > 1 - \lambda\}$$

**Lemma 2.1** ([8]) If  $\varepsilon_1 \leq \varepsilon_2$  and  $\lambda_1 \leq \lambda_2$ , then  $N_p(\varepsilon_1, \lambda_1) \subset N_p(\varepsilon_2, \lambda_2)$ .

**Theorem 2.1** If  $(X, f)$  is a Menger PN-space and  $\lim_{x \rightarrow 1} T(a, x) = a$ , then  $(X, f)$  is Hausdorff in the topology induced by the family  $\{N_p(\varepsilon, \lambda)\}$  of  $(\varepsilon, \lambda)$ -neighborhood.

**Proof.** Firstly, we prove that for every  $p \in X$ , there exists at least one nbd  $N_p$  of  $p$  and every nbd of  $p$  contains  $p$ . For every  $\varepsilon > 0$  and every  $\lambda > 0$ ,  $p \in N_p(\varepsilon, \lambda)$  since  $f_p(\varepsilon) = 1$ .

Secondly, we prove if  $N_p^1, N_p^2$  are nbds of  $p$ , then there exists a nbd  $N_p^3$  such that  $N_p^3 \subset N_p^1 \cap N_p^2$ . To see this, let

$$N_p^1(\varepsilon_1, \lambda_1) = \{q : f_{p-q}(\varepsilon_1) > 1 - \lambda_1\}$$

$$N_p^2(\varepsilon_2, \lambda_2) = \{q : f_{p-q}(\varepsilon_2) > 1 - \lambda_2\}$$

be the given nbds of  $p$ .

Consider  $N_p^3 = \{q : f_{p-q}(\varepsilon) > 1 - \lambda\}$  where  $\varepsilon = \min\{\varepsilon_1, \varepsilon_2\}$  and  $\lambda = \min\{\lambda_1, \lambda_2\}$ .

Then clearly  $p \in N_p^3$ , by lemma 2.1  $N_p^3 \subset N_p^1$  and  $N_p^3 \subset N_p^2$  and so  $N_p^3 \subset N_p^1 \cap N_p^2$ .

Now, we shall show that, if  $N_p$  is a nbd of  $p$  that contains  $q$ , then there exists a nbd  $N_q$  such that  $p \in N_q \subset N_p$ . To see this, let  $N_p = \{r : f_{p-r}(\varepsilon_1) > 1 - \lambda_1\}$  be such a nbd of  $p$ . Since  $q \in N_p$ , then  $f_{p-q}(\varepsilon_1) > 1 - \lambda_1$ .

Now,  $f_{p-q}$  is left continuous at  $\varepsilon_1$ . Hence there exists  $\varepsilon_0 < \varepsilon_1$  and  $\lambda_0 < \lambda_1$  such that

$$f_{p-q}(\varepsilon_0) > 1 - \lambda_0 > 1 - \lambda_1.$$

Let  $N_q = \{r : f_{q-r}(\varepsilon_2) > 1 - \lambda_2\}$ , where  $0 < \varepsilon_2 < \varepsilon_1 - \varepsilon_0$  and  $\lambda_2$  is chosen such that  $T(1 - \lambda_0, 1 - \lambda_2) > 1 - \lambda_1$ . Such a  $\lambda_2$  exists, since by hypothesis  $\lim_{x \rightarrow 1} T(a, x) = a$  and  $1 - \lambda_0 > 1 - \lambda_1$ .

Now, suppose  $s \in N_q$  so that  $f_{q-s}(\varepsilon_2) > 1 - \lambda_2$ . Then we have

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$$\begin{aligned} f_{p-s}(\varepsilon_1) &\geq T(f_{p-q}(\varepsilon_1 - \varepsilon_0), f_{q-s}(\varepsilon_0)) \geq T(f_{p-q}(\varepsilon_0), f_{q-s}(\varepsilon_2)) \\ &\geq T(1 - \lambda_0, 1 - \lambda_2) > 1 - \lambda_1. \end{aligned}$$

But this means that  $s \in N_p$ , and so  $N_q \subset N_p$ .

Finally, we show that if  $p \neq q$ , then there exist disjoint nbds  $N_p, N_q$  such that

$$p \in N_p, q \in N_q, N_p \cap N_q = \phi.$$

To do this, let  $p \neq q$ , then there exists an  $x$  and an  $a, 0 \leq a < 1$  such that  $f_{p-q}(x) = a$ . Let  $N_p = \{r : f_{p-r}(\frac{x}{2}) > b\}$  and  $N_q = \{r : f_{q-r}(\frac{x}{2}) > b\}$ , where  $b$  is chosen so that  $0 < b < 1$  and  $T(b, b) > a$ . Such a number  $b$  exists, since  $\lim_{x \rightarrow 1} T(a, x) = 1$  and  $T(1, 1) = 1$ .

Now, suppose that there is a point  $s$  in  $N_p \cap N_q$  so that  $f_{p-s}(\frac{x}{2}) > b$  and  $f_{q-s}(\frac{x}{2}) > b$ .

Then we have

$$a = f_{p-q}(x) \geq T(f_{p-s}(\frac{x}{2}), f_{s-q}(\frac{x}{2})) \geq T(b, b) > a,$$

which is a contradiction. Thus  $N_p$  and  $N_q$  are disjoint.

**Definition 2.2** ([1]) A sequence of points  $\{p_n\}$  in a PN-space is said to converge to a point  $p$  in  $X$  (we write  $p_n \rightarrow p$ ) if and only if for every  $\varepsilon > 0$  and every  $\lambda > 0$  there exists an integer  $M_{\varepsilon, \lambda}$  such that  $p_n \in N_p(\varepsilon, \lambda)$  *i.e.*,  $f_{p_n-p}(\varepsilon) > 1 - \lambda$  whenever  $n > M_{\varepsilon, \lambda}$ .

**Lemma 2.2** ([9]) If  $p_n \rightarrow p$ , then  $f_{p_n-p}(\varepsilon) = 1$ .

**Theorem 2.2** If  $(X, f)$  is a Menger PN-space and  $\lim_{x \rightarrow 1} T(a, x) = 1$ , then the probabilistic function  $f$  is a lower semi-continuous function of points. *i.e.*, for every fixed  $x$ , if  $p_n \rightarrow p$  and  $q_n \rightarrow q$ , then  $\liminf_{n \rightarrow \infty} f_{p_n-q_n}(x) = f_{p-q}(x)$ .

**Proof.** If  $x = 0$ , since for every  $n, f_{p_n-q_n}(0) = 0 = f_{p-q}(0)$ , the theorem follows immediately.

Suppose then that  $x > 0$  and let  $\varepsilon > 0$  be given. Since  $f_{p-q}$  is left continuous at  $x$ , there is an  $h, 0 < 2h < x$  such that

$$f_{p-q}(x) - f_{p-q}(x - 2h) < \frac{\varepsilon}{2} \quad (1)$$

Set  $f_{p-q}(x - 2h) = a$ . Since  $\lim_{x \rightarrow 1} T(a, x) = 1 = T(a, 1)$ , there is a number  $t, 0 < t < 1$ , such that  $T(a, t) > a - \frac{\varepsilon}{3}$  and  $T(a - \frac{\varepsilon}{3}, t) > a - \frac{2\varepsilon}{3}$ .

Since  $q_n \rightarrow q$  and  $p_n \rightarrow p$ , then by lemma 2.2 there exists an integer  $M_{\varepsilon, \lambda}$  such that  $f_{p_n-p}(h) > t$  and  $f_{q_n-q}(h) > t$  whenever  $n > M_{\varepsilon, \lambda}$ . Now we have

$$f_{p_n-q_n}(x) \geq T(f_{p_n-q}(x-h), f_{q_n-q}(h)) \quad (2)$$

and

$$f_{p_n-q}(x-h) \geq T(f_{p-q}(x-2h), f_{p-p_n}(h)) \quad (3)$$

Thus, on combining the inequalities (2) and (3), we obtain

$$f_{p_n-q}(x-h) \geq T(a, t) > a - \frac{\varepsilon}{3}.$$

Thus, we have

$$f_{p_n-q_n}(x) \geq T(a - \frac{\varepsilon}{3}, t) > a - \frac{2\varepsilon}{3} > f_{p-q}(x) - \varepsilon. \quad (4)$$

**Corollary 2.1** Let  $p$  be a fixed point and suppose  $q_n \rightarrow q$ , then

$$\liminf_{n \rightarrow \infty} f_{p-q_n}(x) = f_{p-q}(x).$$

**Proof.** Since  $q_n \rightarrow q, p \rightarrow p$ , then the result follows immediately from Theorem 2.6.

Recall that a function  $f : X \times Y \rightarrow \mathbb{R}$  is said to be lower-upper semi-continuous if  $x \mapsto f(., y)$  and  $y \mapsto f(x, .)$  are lower and upper semi-continuous, respectively.

**Theorem 2.3** Let  $(X, f)$  be a Menger PN-space. Suppose that  $\lim_{x \rightarrow 1} T(a, x) = 1$  and

$T(a, b) = \max(a + b - 1, 0)$ . Suppose further that  $p_n \rightarrow p, q_n \rightarrow q$  and that

$f_{p-q}$  is continuous at  $x$ . Then

$f_{p_n-q_n}(x) \rightarrow f_{p-q}(x)$ , i.e., the distance function  $f$  is a continuous function

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of points at  $(p, q)$ , or expressed in another way, the sequence of functions  $\{f_{p_n-q_n}\}$  converges weakly to  $f_{p-q}$ .

**Proof.** It suffices to prove the upper-semi continuity of  $f_{p-q}$ , i.e., that for every  $\varepsilon > 0$  and  $n$  sufficiently large

$$f_{p_n-q_n}(x) < f_{p-q}(x) + \varepsilon \quad (5)$$

Suppose  $\varepsilon > 0$  is given. Since  $f_{p-q}$  is right continuous at  $x$ , then there exists an  $h > 0$  such that

$$f_{p-q}(x+2h) - f_{p-q}(x) < \frac{\varepsilon}{3} \quad (6)$$

By lemma 2.2 there exists an integer  $M$  such that

$$f_{p-p_n}(h) > 1 - \frac{\varepsilon}{3} \quad (7)$$

and

$$f_{q-q_n}(h) > 1 - \frac{\varepsilon}{3} \quad (8)$$

are simultaneously satisfied for all  $n > M$ .

Now, by condition  $(PN - 4)$ , we have

$$f_{p-q}(x+2h) \geq T(f_{p-q_n}(x+h), f_{q_n-q}(h)) \quad (9)$$

and

$$f_{p-q_n}(x+h) \geq T(f_{p-p_n}(h), f_{p_n-q_n}(x)) \quad (10)$$

Since  $T(a, b) = \max(a + b - 1, 0)$ , then we have

$$f_{p-q_n}(x+h) \geq f_{p_n-q_n}(x) + f_{p-p_n}(h) - 1 > f_{p_n-q_n}(x) - \frac{\varepsilon}{3} \quad (11)$$

and on combining (7) with (4) and (5), we have

$$\begin{aligned} f_{p-q}(x+2h) &\geq f_{p-q_n}(x+h) + f_{q_n-q}(h) - 1 \\ &> f_{p_n-q_n}(x) + f_{q_n-p}(h) - 1 \\ &> f_{p_n-q_n}(x) - \frac{2\varepsilon}{3} \end{aligned} \quad (12)$$

Therefore, combining (12) with (6) yields (5).

As a consequence of Theorem 2.3, we have immediately

**Corollary 2.2** Let  $(X, f)$  be a Menger PN-space. Suppose that  $\lim_{x \rightarrow 1} T(x, a) = a$  and  $T(a, b) = \max(a, b)$ . Suppose further that  $q_n \rightarrow q$  and that  $f_{p-q}$  is continuous at  $x$ . Then  $f_{p-q_n}(x) \rightarrow f_{p-q}(x)$ .

**Definition 2.3** A  $t$ -norm  $\Delta$  is said to be semi-continuous, if  $\Delta$  is semi-continuous in each place. A continuous  $t$ -norm  $\Delta$  is said to be Archimedean if for each  $t \in (0,1), \Delta(t, t) < t$ .

Let  $\Delta$  be a continuous  $t$ -norm satisfying the following condition:

$$\sup \Delta(t, t) = 1$$

Using the  $t$ -norm  $\Delta$ , we define a triangle function  $\tau$  by

$$\tau(F, G)(t) = \sup \{ \Delta(F(\alpha t), G(\beta t)) : \alpha, \beta \geq 0, \alpha + \beta = 1 \}, F, G \in D^+. \quad (13)$$

Let  $\tau$  be a triangle function and let  $\{F_n\}_{n=1}^\infty$  be a sequence of distribution functions in  $D^+$ . Denote

$$\tau_{i=1}^1 F_i = \tau(F_1, F_2), \quad \tau_{i=1}^n F_i = \tau(\tau_{i=1}^{n-1} F_i, F_{n+1}), n = 2, 3, \dots$$

The problem is that the triangle norm in a PN-space is often not strong enough to guarantee that the sequence of iterates of a point under a contraction mapping is a Cauchy sequence. In what follows, we shall give some examples to show that it is possible to construct complete PN-space together with contraction mappings which have no fixed point.

**Theorem 2.4** Let  $\Delta$  be a semi-continuous  $t$ -norm and let  $\tau$  be the semi-continuous  $t$ -function defined by (1). Then there exists a complete Serstnev PM-space  $(X, f)$  under  $\tau$  and a contraction map  $T$  on  $(X, f)$  which has no fixed point if and only if there exists a  $G \in D^+$  and a number  $\alpha \in (0,1)$  such that

$$\sup \{ (\tau_{i=1}^\infty G(j / \alpha^{i-1}))(x) : x \in R \} < 1,$$

where  $j : R \rightarrow R$  is the identity function.

**Proof.** Suppose, for every  $G \in D^+$  and for every  $\alpha \in (0,1)$ , that

$$\sup \{ (\tau_{i=1}^\infty G(j / \alpha^{i-1}))(x) : x \in R \} = 1.$$

**On the Continuity and Fixed Point Theorem in the PN-Space**

Let  $T$  be a contraction mapping on the complete Serstnev PM-space  $(X, f)$  under  $\tau$ . We shall show that  $T$  has a fixed point. To do this, let  $p_0 \in X$  and let  $\{p_n\}$  be the sequence of iterates of  $p_0$  under  $T$ . Then for some  $\alpha \in (0,1)$ , we have

$$F_{p_0, p_m} \geq \tau_{i=1}^m F_{p_0, p_1}(j/\alpha^{i-1}) \geq \tau_{i=1}^\infty F_{p_0, p_1}(j/\alpha^{i-1}).$$

Thus, we have

$$G_{p_0} \geq \tau_{i=1}^\infty F_{p_0, p_1}(j/\alpha^{i-1})$$

and it follows from [11] that  $T$  has a fixed point. Conversely, suppose that  $G \in D^+$  and  $\alpha \in (0,1)$  are such that

$$\sup\{\tau_{i=1}^\infty G(j/\alpha^{i-1})(x) : x \in R\} < 1.$$

We shall define a probabilistic distance function  $f$  on  $Z^+$  such that  $(Z^+, f)$  is a complete Serstnev PM-space under  $\tau$  and show that the mapping  $T$  taking  $n$  to  $n+1$ , which obviously has no fixed point, is a contraction mapping. For any  $n, m \in Z^+$ , define

$$F_{n+m, n} = F_{n, n+m} = \tau_{i=1}^m G(j/\alpha^{n+i-1})$$

and let

$$F_{n, n} = H$$

With this definition of  $f$ , (PM-1)-(PM-4) are clearly satisfied. Thus we have only to verify that  $(Z^+, f)$  satisfies  $F_{x,y}(t) \geq \tau(F_{x,z}, F_{z,y})(t)$ ,  $x, y, z \in X, t \geq 0$ , under  $\tau$ . Case splitting shows that this will follow from the following three inequalities:

- (1)  $F_{n, n+m+k} \geq \tau(F_{n, n+m}, F_{n+m, n+m+k})$ ,
- (2)  $F_{n, n+m} \geq \tau(F_{n, n+m+k}, F_{n+m+k, n+m})$ ,
- (3)  $F_{n+m, n+m+k} \geq \tau(F_{n+m, n}, F_{n, n+m+k})$ ,

**Case (1):** Since  $\tau$  is associative,

$$\begin{aligned} F_{n,n+m+k} &= \tau_{i=1}^{m+k} G(j/\alpha^{n+i-1}) \\ &= \tau(\tau_{i=1}^m G(j/\alpha^{n+i-1}), \tau_{i=m+1}^{m+k} G(j/\alpha^{n+i-1})) \\ &= \tau(F_{n,n+m}, \tau_{i=1}^k G(j/\alpha^{n+m+i-1})) \\ &= \tau(F_{n,n+m}, F_{n+m,n+m+k}). \end{aligned}$$

**Case (2):** For any  $F, G \in D^+$ ,  $F = \tau(F, H) \geq \tau(F, G)$ , also  $\tau$  is associative.

Thus we have

$$\begin{aligned} F_{n,n+m} &= \tau_{i=1}^m G(j/\alpha^{n+i-1}) \\ &\geq \tau(\tau_{i=1}^m G(j/\alpha^{n+i-1}), \tau_{i=m+1}^{m+k} G(j/\alpha^{n+i-1})) \\ &= \tau_{i=1}^{m+k} G(j/\alpha^{n+i-1}) \\ &= F_{n,n+m+k} \\ &\geq \tau(F_{n,n+m+k}, F_{n+m+k,n+m}). \end{aligned}$$

**Case (3):** The proof is similar to the proof given in case (2) and is therefore omitted.

It will now be shown that  $(Z^+, f)$  is complete by showing that the only Cauchy sequences are those which are eventually constant. Suppose  $\{p_n\}$  is a sequence in  $Z^+$  which is not eventually constant. Then either

- (i) there is a positive integer  $N$  such that  $p_n \leq N$  for all  $n \in Z$  or
- (ii) For every positive integer  $k$  there exists a positive integer  $n_k$ , such that  $p_{n_k} > p_{n_{k-1}}$ , where  $n_0 = 1$ .

**Case (i):** Since  $\{p_n\}$  is not eventually constant it follows that for every positive integer  $K$ , there exist  $n, m > K$  such that  $p_m \neq p_n$  and whence we have

$$F_{p_m, p_n}(t) \leq \max\{F_{i,k}(t) : 0 \leq i, j \leq N, i \neq j\} < H(t)$$

for some  $t > 0$ . Thus  $\{p_n\}$  is not Cauchy sequence.

**Case (ii):** Suppose in addition that  $\{p_n\}$  is a Cauchy sequence in  $(Z^+, f)$ . It is easy to show by consideration of the isometric image of this sequence in the completion of

**On the Continuity and Fixed Point Theorem in the PN-Space**

$(Z^+, f)$  that the limit function  $\lim_{k \rightarrow \infty} F_{1, p_{n_k}}$  Is a distribution function and therefore has one as its supremum. However, for any real  $x$ , we have

$$\begin{aligned} \lim_{k \rightarrow \infty} F_{1, p_{n_k}} &= \lim_{k \rightarrow \infty} (\tau_{i=1}^{p_{n_k}-1} G(j / \alpha^{1+i-1}))(t) \\ &= \lim_{k \rightarrow \infty} \sup \{ (\tau_{i=1}^{p_{n_k}-1} G(\beta_i t / \alpha^i)) : \sum_{i=1}^{p_{n_k}-1} \beta_i = 1, 0 \leq \beta_i \leq 1 \} \\ &= \lim_{k \rightarrow \infty} \tau_{i=1}^{p_{n_k}-1} G(j / \alpha^{i-1})(t / \alpha) \\ &= \tau_{i=1}^{\infty} G(j / \alpha^{i-1})(t / \alpha). \end{aligned}$$

The supremum of this quantity for real  $t$  is strictly less than one, and we have arrived at a contradiction. Thus  $(Z^+, f)$  is complete.

Finally, to see that the mapping  $T : Z^+ \rightarrow Z^+$  defined by  $T(n) = n + 1, \forall n \in Z^+$  is a contraction mapping, it suffices to note that for  $n > m$  positive integers and  $t > 0$ , we have

$$\begin{aligned} F_{m+1, n+1}(t) &= (\tau_{i=1}^{n-m} G(j / \alpha^{m+i}))(t) \\ &= \sup \{ \tau_{i=1}^{n-m} G(\beta_i t / \alpha^{m+i}) : \sum_{i=1}^{n-m} \beta_i = 1, 0 \leq \beta_i \leq 1 \} \\ &= (\tau_{i=1}^{n-m} G(j / \alpha^{m+i-1}))(t / \alpha) \\ &= F_{m, n}(t / \alpha). \end{aligned}$$

This completes the Proof.

We end this paper by illustrating the following examples which satisfy Theorem 2.4

**Example 1.** Let  $\alpha$  be any real number with  $0 < \alpha < 1$  and let  $G$  be defined as follows

$$G(t) = \begin{cases} 0, & \text{if } t \leq \frac{1}{\alpha^3} \\ 1 - \left(\frac{1}{2n}\right), & \text{if } \frac{1}{\alpha^n} < t \leq \frac{1}{\alpha^{n+2}}, n > 2. \end{cases}$$

Define the triangle function  $\tau$  by

$$\tau(F,G)(t) = \sup\{\Delta(F(\alpha(t)),G(\beta(t))) : \alpha, \beta \geq 0, \alpha + \beta = 1\},$$

where  $\Delta(a,b) = \min\{a,b\}$ .

Let  $F : Z^+ \rightarrow Z^+$  by  $T(n) = n + 1$  then  $T$  is a contraction mapping.

Therefore, we see that the conditions of Theorem 2.4 are satisfied.

**Example 2.** Let  $\alpha$  be any real number with  $0 < \alpha < 1$  and let  $G$  be defined as follows

$$G(t) = \begin{cases} 0, & \text{if } t \leq \frac{1}{\alpha^3} \\ 1 - \left(\frac{1}{2n}\right), & \text{if } \frac{1}{\alpha^n} < t \leq \frac{1}{\alpha^{n+2}}, n > 2. \end{cases}$$

Define the triangle function  $\tau$  by

$$\tau(F,G)(t) = \sup\{\Delta(F(\alpha(t)),G(\beta(t))) : \alpha, \beta \geq 0, \alpha + \beta = 1\},$$

where  $\Delta(a,b) = \text{product}\{a,b\} = ab$

Let  $F : Z^+ \rightarrow Z^+$  by  $T(n) = n + 1 \Rightarrow T$  is a contraction mapping.

So, we see that the conditions of Theorem 2.4 are satisfied.

## حول الاتصال ونظرية القيمة الثابتة في الفضاء الطبيعي الاحتمالي

راتب البطوش، محمد حسين رشيد، باسم مساعده

### ملخص

في هذا البحث سنقوم بإعادة هيكلة البناء التبولوجي لفضاء الطبيعي الاحتمالي لمينجر وذلك تحت تأثير اقتران  $t$ -الطبيعي. وسنقوم بإعطاء أمثلة لإثبات انه من الممكن بناء فضاء طبيعي احتمالي جنباً إلى جنب مع اقتران الانكماش بحيث ليس لها نقطة ثابتة.

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## Development of a Customer Loyalty System

Rizik Al-Sayed\*, Mannam Zamzeer\*, Mo'taz Al -Sa'eed\*\* and Yousef Majdalawi\*<sup>1</sup>

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### Abstract

Due to rapid global economic growth, the competition within markets has increased, requiring organizations to acquire and sustain a competitive advantage in today's information-based on digital business environment. Organizations must take more creative steps in their use of information technology to make their business more attractive to customers rather than their competitors. Loyalty programs are a prime example of keeping a competitive edge in today's market. The success of these programs rely on keeping track of the activities and accounts of many, perhaps even millions of customers, which would not be without a customer loyalty system. Thus, this paper introduces the development of a customer loyalty system which can compute, generate, and provide reports to the business stakeholders concerning their work, customers, and their market share (growth). Managers can then easily learn how to use this system and integrate it within their other business applications.

**Keywords:** Customer loyalty, Short Message Service (SMS), American Customer Satisfaction Index (ACSI), Web Customer Satisfaction Index (WCSI), Customer to business (C2B).

### Introduction

Loyalty programs play a major role in business growth by retaining the present customers and attracting potential ones. In order to achieve these roles, organizations should have a powerful customer loyalty system which gathers valuable information concerning customers' purchasing frequency, purchasing interests and their spending practices. Customer information will be analyzed by the customer loyalty system and utilized to create useful promotion and reward plans.

Much has been written about loyalty program implementation and ideas. Cheung & Lee in [1] have empirically tested the asymmetric and nonlinear information system user satisfaction model in the context of Internet-based portals, with a purpose to examine the asymmetric and nonlinear nature of links involved in satisfaction judgment. The information quality of the content of the Internet-based portal is the most important and relevant variable to determine user satisfaction. Information quality has been defined as the extent to which users think that information is appropriate, up-to-date, accurate, and complete. The findings of their study have shown that there exists a positive-negative asymmetry in the user satisfaction model. The negative perceived performance of the

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\* King Abdullah II School for Information Technology, The University of Jordan, Amman, Jordan.

\*\* Department of Accounting and Accounting Information, Al- Balqa' Applied University, Al-Salt, Jordan.

information-quality attribute has a greater impact than the positive perceived performance (except in the case of the completeness-of- information quality where there was some support for diminishing returns in the domain of negative perceived performance of information-quality attributes, but not in the domain of positive perceived performance).

Lilly, *et al.* in [2] has empirically examined the effects of using customer terminology on loyalty behaviors. A total of 273 subjects participated in the experimental study. The findings underlined the importance of providing excellent service. However, using customer terminology did not significantly affect loyalty. Thus, organizations that have only adopted customer terminology as a relationship marketing instrument probably won't be realizing their expected gains.

Tian & Zhang in [3] have proposed an iterative model which is based on the traditional American Customer Satisfaction Index (ACSI). First, they discussed the foundation of building the model called Web Customer Satisfaction Index (WCSI) where four aspects of social relation, psychology, behavior and the ACSI working fields were defined. Then, the model methodology was discussed which is used to collect data from users' records, like average clicking rate, and figuring out the score of service quality by using the factor analysis method. They discovered that the index system based on customer behavior of WCSI model is more applicable than the survey based ACSI to a network environment.

Xue & Liang in [4] studied factors which influence customer loyalty within the telecommunication industry to investigate the formation mechanism and development and control of Customer Loyalty by applying the data mining. They discovered that there is neither a single behavior loyalty, nor a single attitude loyalty. From the view of consumer behavior, before purchasing, while purchasing, and after purchasing, consumer's rational judgments are all permeated.

Li and Jiang in [5] have produced a detailed evaluation of indicators which includes customer confidence, enterprise visualization, customer value, communication apparatus, and customer satisfaction. They have evaluated the relational factors that affect customer loyalty and set up the proportion distribution of these factors. Based on their analysis, they put forward marketing strategies founded on product and customer divergence.

Bolton et al in [6] has investigated the conditions under which a loyalty reward program will have a positive effect on customer evaluations, behavior, and repeat purchase intentions. The findings of the study showed that members of a loyalty reward program overlook or discount negative evaluations of the company vis-à-vis competition. The authors concluded that members of the loyalty rewards program probably perceive that they are getting better quality and service for their price (a good value).

Huang et al in [7] has empirically investigated whether loyalty programs indeed build customer loyalty or just merely create habitual repeated patronage in the casino industry. The study has found that monetary rewards, special treatment rewards, and employee interaction rewards significantly and positively influenced customer

## **Development of a Customer Loyalty System**

satisfaction with loyalty programs. However, timing of the rewards had a minimal impact on customer satisfaction with the loyalty programs. The results of this study indicated that customer satisfaction with loyalty programs has no effect on customer loyalty. Casino managers then should note that using only loyalty programs is not sufficient enough to create customer loyalty. The results of this study has had some similarities with the results of Hennig et al [8] like social and confidence benefits leading to customer loyalty. Instead of spending money to give away free hotel room stays, or free meals, casino managers might consider providing intangible rewards to customers to enhance their satisfaction and loyalty.

Wolfenbarger and Gilly in [9] have found that offering goal-oriented online customers with what they want, when they want it, and answering inquiries with no delay creates loyalty, even if these customers are not interested in being entertained while shopping online.

This paper introduces the development of customer loyalty systems. These systems are simple, flexible, and user friendly. The developed systems enable organizations to update their promotion and reward strategies based on actual feedback data from customers.

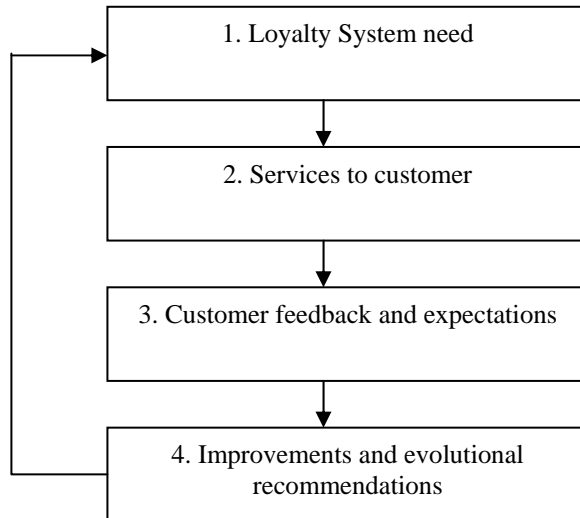
As a methodology for this study, we developed loyalty software that focused on delivering promotions to customers' mobile phones using SMS services. The developed system addresses the common Customer Relationships Management (CRM Systems) principles.

The organization of this paper is divided into sections. Section 2 introduces the development of a customer loyalty system, which includes system components, description, functional and non-functional requirements, design of the model, model use cases and the description to basic screens are covered. Section 3 covers the testing and the evaluation of the model. In section 4 the model improvements are covered and the conclusion is drawn in section 5.

### **Customer Loyalty Model Development**

This paper presents the development and implementation of a customized loyalty system focusing on delivering promotions to customers' mobile phones using SMS services that allow the company to communicate with customers individually and effectively to reduce the marketing costs of these promotions.

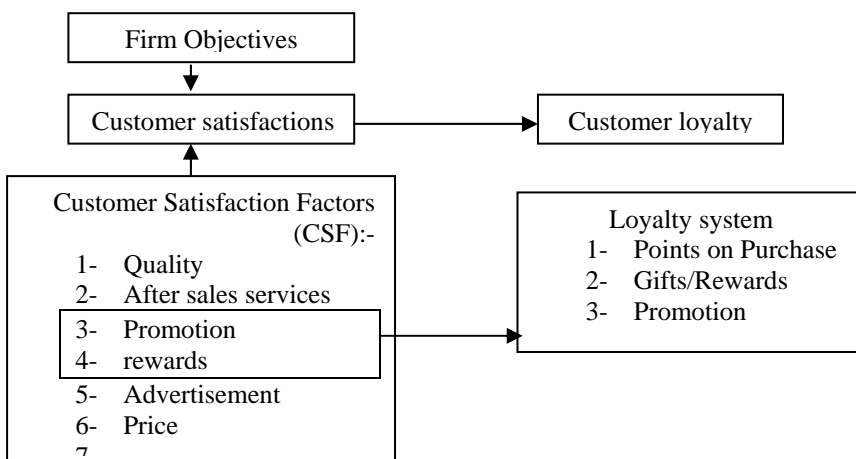
The developed model requires the examination of four major stages. These stages are shown in Figure 1. As shown in Figure 1, there is an imperative need for a loyalty system which represents the first stage in our model. The second stage is identifying the services that will be offered to the customer. By skipping many details and jumping to the implementation stage, the customer feedback and expectations are collected and placed for further processing which represents the third stage. The fourth stage is associated with the decisions that should be made about the improvements and the evolutionary recommendations which will be fed back to the first stage and thus the cycle continues.



**Fig. 1:** Block diagram for the customer loyalty system stages.

The Developed loyalty system requires the firm to set the following components which are shown in Figure 2. The firm should first setup its objectives. Among other factors, customer satisfaction plays a major role. There are many factors that have high impact on customer satisfaction including quality, after sales service, promotions, gifts and rewards, advertisements, competitive prices and others. This study addresses mainly two issues namely promotion and gifts and rewards. Customer satisfaction has a direct and positive impact on customer loyalty.

This study examines three loyalty components: granting points, on the amount of purchasing, granting rewards based on the accumulated points and promotion via different communication channels.



**Fig. 2:** Block diagram for the proposed Loyalty Model.

## **Development of a Customer Loyalty System**

### **The Loyalty System Components**

The proposed loyalty system mainly addresses the communication channels and offered services, namely, the point's calculation method, the reward policy and the promotion policy.

Communication channels and their offered services cover three "customer to business" (C2B) channels: direct access to store, web site access and SMS messages. The services cover direct access to store include: (1) purchasing, (2) points query, (3) rewards query, (4) promotion available and (5) rewards selection. From the web site services, the customer can make query about: the accumulated points, the deserved rewards and the available promotions. The SMS services can be used for informing customers about his or her granted points for each purchase and any available promotions.

Regarding the points calculation methods, each currency unit for a specific product (such as JD and USD) has a set of points that should be clearly conveyed to customer. Those points are normally set by the manager.

With respect to the rewards granting policy, the model addresses a fixed rewarding policy, and from time to time, the manager can make changes on the offered rewards. These rewards are limited to specific products.

In the promotion policy, the model does not have a clear promotion policy. The manager decides the time and the product to be promoted.

### **The System Description**

Many business corporations focus their efforts on increasing revenues by reducing their costs and increasing the quality of service provided to the customers. As this process continues over a long time, new problems and challenges arise, like how to keep the present customers, increase their purchases and maintain a list of their actual needs and interests. In addition, how to invest efforts in order to attract new ones.

The researchers started to gather information about hardware retail stores problems and needs. In studying one of these stores, they found that one store has over 10,000 customers to serve monthly. However, when it come to gathering valuable purchase information such as purchasing frequency, interests, spending, ...etc, and analyzing of this information to make targeted promotions and rewards, there was no actual efficient system the managers to benefit from in order to increase the customers average buying and to gain their loyalty while increasing their satisfaction.

As a methodology for this study, we implemented customized loyalty software that focused on delivering promotions to customers' mobile phones using SMS services. This in turn, allows the store to communicate with customers individually, effectively, and conveniently to reduce the marketing costs of these promotions.

The system will provide lists of products and their prices, categories, other details, and a table of points for each product/category. The administrator can then enter the desired number of points to each JD, along with a list of customers containing their purchases and points. Depending on the customer points, the system will generate a gift

or promotion and send a report about this to the customer via SMS service or Email. The website will be updated for future promotions. The system will also provide useful reports such as the best customer, the best buyer, the best purchasing customer, average sales per month, and the best and worst sales category.

### **Functional and Non-functional Requirements**

To give a better picture about the proposed model, it is worth introducing both the functional and non-functional requirements.

#### ***Functional Requirements***

The stakeholders of this system comprise the administrator, the cashier, and the customer. The following list shows the major functions that the system must allow the *administrator* to perform:

1. Authorization to set an account for him/herself with all privileges and another one for the cashier to *access* the system.
2. The ability to delete customers' accounts.
3. The ability to view/edit customer account information.
4. The ability to set the points *per* currency unit (JD...etc) ratio.
5. The ability to send to customers customizable SMS batches with promotions gifts and/or special offers.
6. The ability to report to the management the average sales for month, the best and the worst seller.
7. The ability to filter customers upon date of birth, average buying, and location.
8. The ability to filter the least 100 purchasing customers per month, and be able to send promotions to them.
9. The ability to view the gifts due to customers' points.
10. The ability to provide an easy way to manage products, add (initiate) products sale, add gifts, and map gifts to points.

The following list shows the major functions that the system must allow the *cashier* to perform:

1. The ability to add new customer accounts.
2. The ability to add a new customer at the store including the customer's full name and mobile number.
3. The ability to save receipt information to the customer's data immediately at any point of sale.
4. The ability to send new customers SMS(s) with their usernames and generate passwords for them.

## Development of a Customer Loyalty System

The following list shows the major functions that the system must allow the *customer* to perform:

1. Through the web site the system must provide a registration form for the new customers to enroll in the program, add their desired usernames and passwords and their mobile numbers, address, and age (through birth date).
2. The ability to login to their accounts and view/update their information, view their points, receipts, gifts, and promotions.
3. The ability to provide to customers an easy way to order their earned gifts online (redeem points).
4. The ability to change a customer's password through the website.
5. The ability to obtain help using the website map.

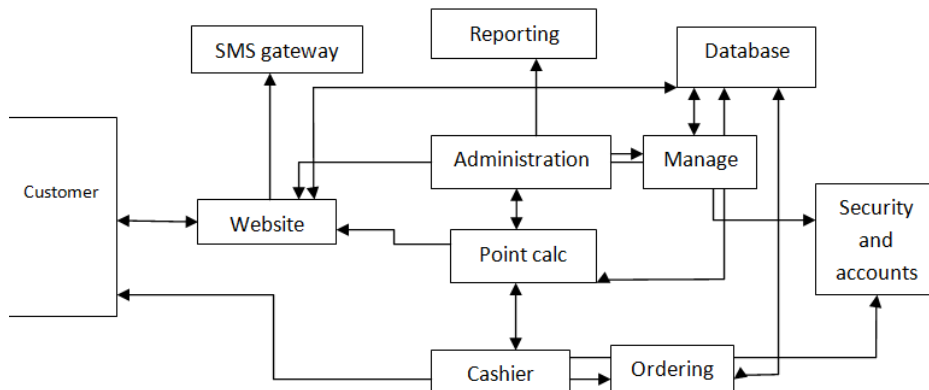
### **Non-Functional Requirements**

The most important non-functional requirements considered in this study are as follows:

1. The system should be easy to use with clearly titled buttons and menus.
2. The interface should be clear enough to show the tasks that can be performed.
3. The system should have a user-friendly design.
4. The system must have the ability to securely backup all data and messages.
5. The system must provide an easy way to manage data.

### **The Model Design**

The block diagram shown in Figure 3 describes the major logical subsystems components of the proposed model.



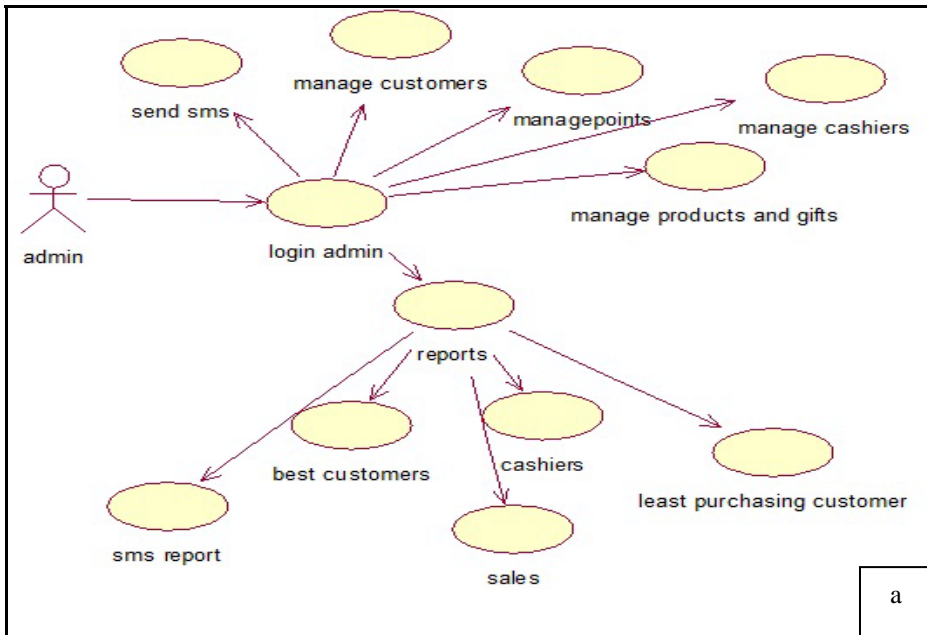
**Fig. 3:** Proposed Model Logical Subsystems.

The proposed model comprises a set of *logical* subsystems. Messages are sent to customers mobiles through the *SMS gateway*. As described above, the *administrator* has full control over the system in terms of managing customers, setting point's ratio,

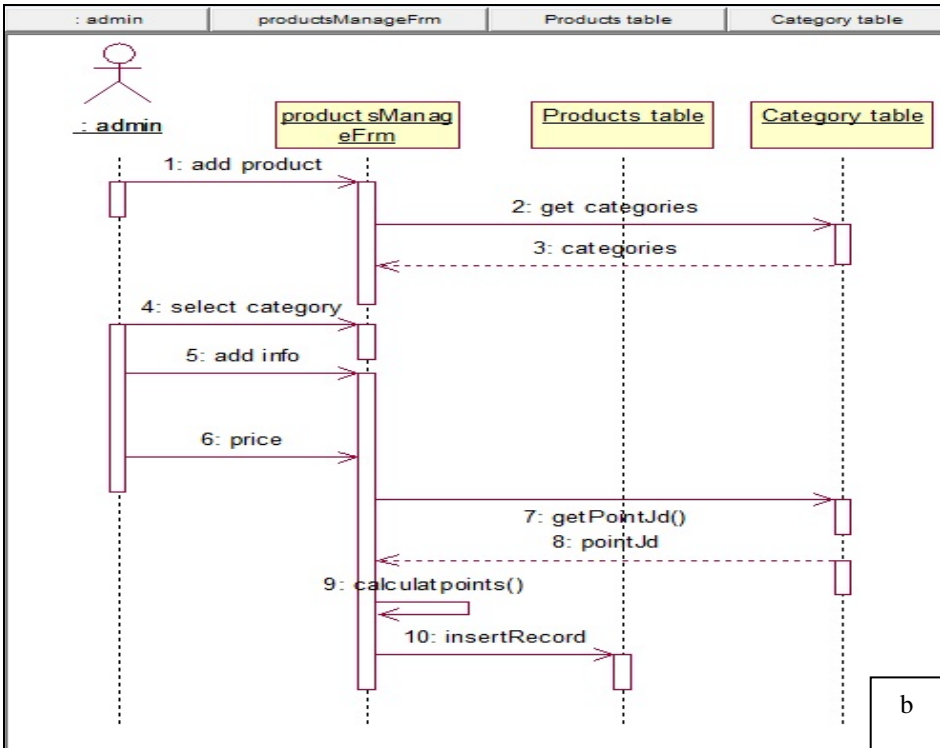
describing the reports required, and dealing with employees' accounts. The *cashier* enters the customer's merchandise into the system. In the *Point calc*, the process of calculating customers' points on products is performed and based on this the *database* is then updated. Managing employees' accounts and privileges occurs in the *Security and accounts* component. In *Ordering*, the cashier enters a customer's specific order of products and gifts. In the *Manage* component, the administrator manages the various subsystems like customers, cashiers, points...etc. The customer can order gifts, manage his/her account information and view his/her points through the *Website*. As a final component, *Reporting* is used to generate certain reports that the system provides such as sales reports and the best customer.

**Use Cases**

Description of the proposed model use cases is presented in this section. Figure 4 – (a) shows the administrator use case and Figure 4 – (b) shows the related sequence diagrams. The administrator is the person who is responsible for the system control panel, where he/she controls the system, generates reports, and manages accounts. The administrator can generate reports related to points and other issues such as the best buyer, the average sales, and the overseeing of cashier's actions by reporting cashier sales, and analyze these reports in a strategic way in order to achieve a company's goal. Also, the administrator can manage the customers' accounts, cashiers' accounts (add new cashier, edit cashier's password ...etc), and also enter the data that is required for the operations of the system.

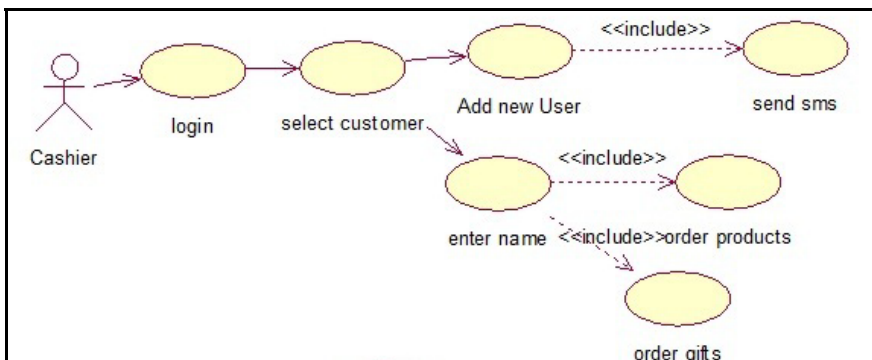


## Development of a Customer Loyalty System



**Fig. 4:** Administrator (a) Use Case Diagram (b) Sequence Diagram

Figure 5 shows the cashier use case diagram. The cashier is the person who is in charge of ordering products and gifts. The cashier, through customized screens, enters customer information and adds this to the database; the entry screen contains an input-box to enter a customer's phone number in order to send the customer an SMS with his/her user name and initial password. This password can be modified later by the customer. The cashier can add purchases for customer and start the ordering process by selecting the customer's name.



**Fig. 5.** Cashier Use Case Diagram.

In Figure 6, customer user case diagram is shown. The customer is the person who buys products. After logging into his/her account on the company’s website, the customer can check his/her point balance, view current offers, and select from available gifts. The customer can enter his/her address on the website to receive the gifts through the delivery service of the company. The customer also has the ability to login to the website, edit his/her personal account information through the edit screen option, and update his/her phone number, name, birthday, and address which will then reflect these changes on the database.

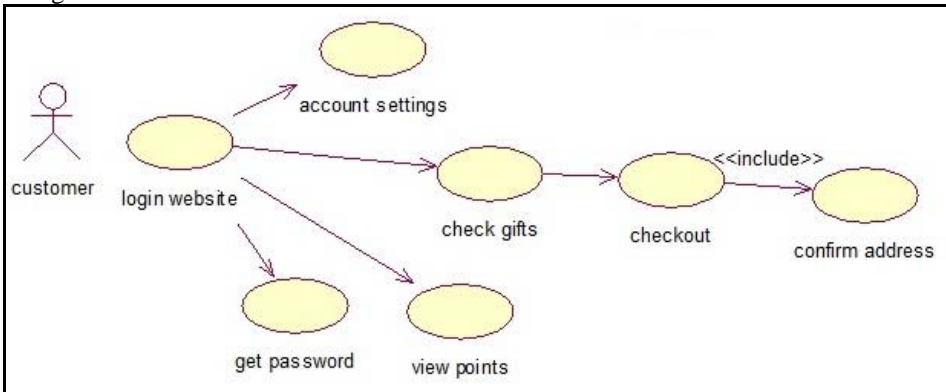


Fig. 6: Customer Use Case Diagram.

### Description of Basic Screens

Screen shots for basic screens will be presented in this section. Figure 7 shows the two main buttons that will be displayed when the system starts. Figure 8 shows the login screen for both the cashier and the administrator. They can login to the system by entering a valid username and a valid password or they can cancel and exit the program.

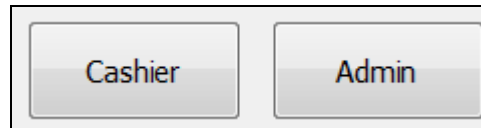


Fig. 7: Main Buttons – Startup Screen.

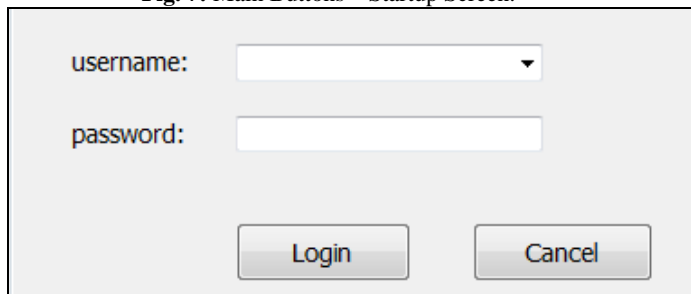


Fig. 8: Cashier Login Screen.

Other screens are available to help the cashier enter a customer’s order; the cashier can view existing customers or can add newer ones.

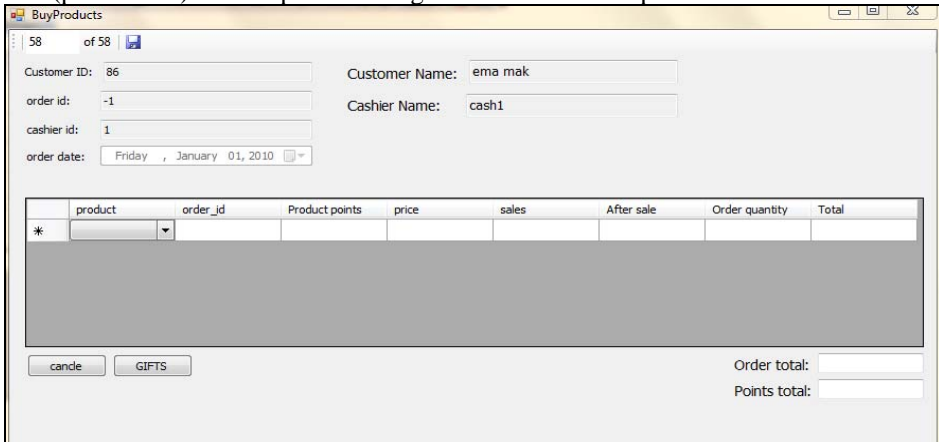
## Development of a Customer Loyalty System



Product points

Points total:

During the purchasing process, the system computes automatically the points deserved (product points) for the customer on each product and accumulates them to the total (points total) of each purchase. Figure 9 illustrates this process.



BuyProducts

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Customer ID:  Customer Name:

order id:  Cashier Name:

cashier id:

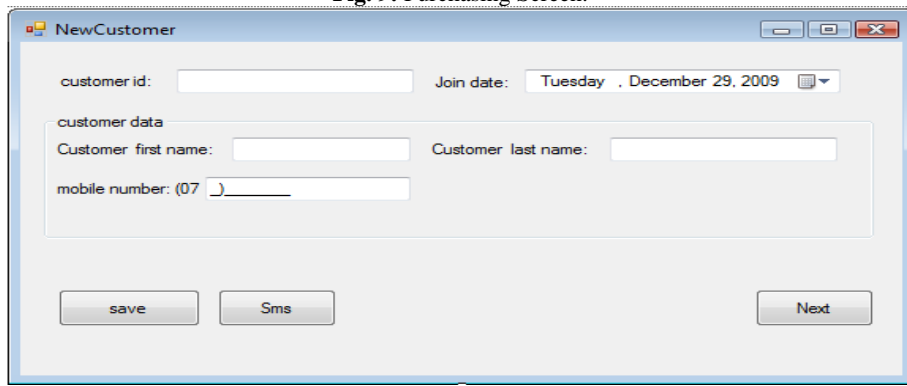
order date:

| product | order_id | Product points | price | sales | After sale | Order quantity | Total |
|---------|----------|----------------|-------|-------|------------|----------------|-------|
| *       |          |                |       |       |            |                |       |

Order total:

Points total:

Fig. 9: Purchasing Screen.



NewCustomer

customer id:  Join date:

customer data

Customer first name:  Customer last name:

mobile number: (07 )

Fig. 10: Adding New customer screen.

Figure 10 shows how the cashier can add a new customer by filling the customer's first name, last name, and mobile number. The ID number of the customer is automatically added. By clicking on the *save* button, the information is committed to the database. By clicking on the *Sms* button, an SMS is sent to the customer with his/her information, and by clicking on the *Next* button enables the cashier to view other customers on the screen.

The administrator controls all processes in the system, such as generating reports, viewing gifts, adding points, and managing SMS. The administrator tasks include: managing cashiers, sending SMS(s), managing customers, and managing gifts and

products. The reports include: Best 10 customers, lowest purchasing customer, sales report, and cashier sales.

Figure 11 shows how the administrator can send an SMS batch to all customers by filling the SMS text, and adding the customers who are entitled to receive the message.

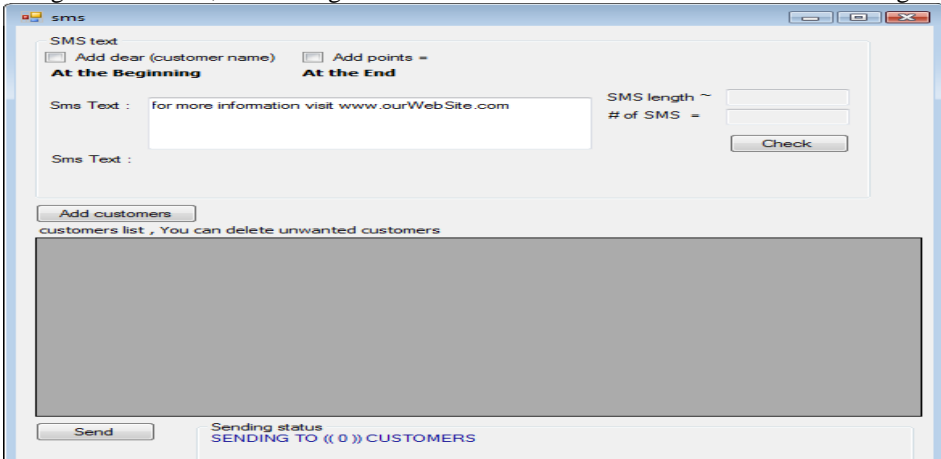


Fig. 11: SMS Screen.

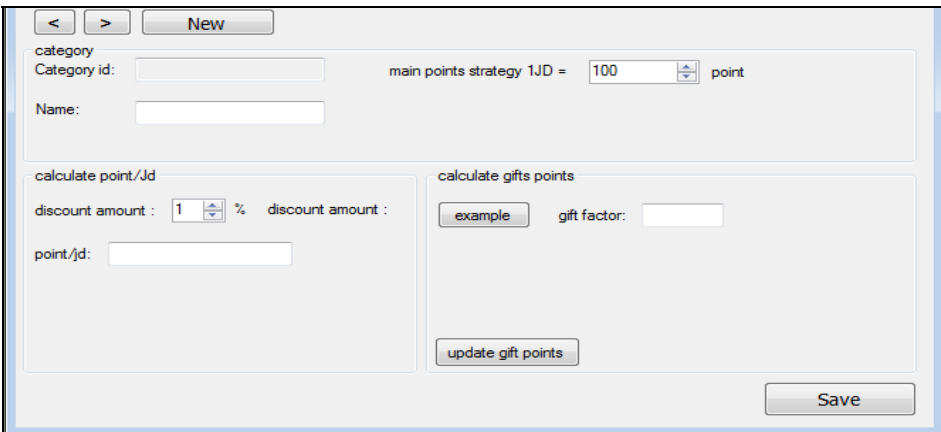


Fig. 12: Category Point Assignment.

As shown in the figure 11, the message can customized by adding dear customer at the beginning and/or adding the amount of the accumulated points at the end.

The administrator can manage the points for the products in the system by assigning points to each product category, and the discount needed on each point (see Figure 12). The administrator can manage all customers stored in the database system by adding, editing, viewing and deleting. In order to analyze the customer in the system efficiently, the administrator can filter the customers based on their points, age, and joining date. Also, the administrator can manage all the cashiers available in the store, by viewing, adding, editing, and deleting.

## Development of a Customer Loyalty System

### The Model Testing and Evaluation

To gather feedback on the proposed model, 115 different customers were asked about their perception of loyalty. For this purpose, a questionnaire with 17 questions was distributed to customers to fill (see Table 1).

In order to analyze the answers of customers by using purchasing frequencies, we transferred the collected data from the 115 customers into spreadsheet software. The accumulative summary to their answers was summarized in Table 2. As shown in Table 2, the questions were grouped into three categories: the points' calculation methods, rewards grants policy and promotion policy. In order to make it easy for the customers to answer the questionnaire, we made the list of questions in the questionnaire short and concentrated on 17 questions in one page.

**Table 1: Loyalty Questionnaire.**

| For the following questions, indicate your answer by typing X in the box that matches your preference.<br><i>Important: Strongly Agree=4, Agree=3, No opinion=2, Disagree=1, and Strongly Disagree=0</i> |  |               |   |   |   |   |
|--|--|---------------|---|---|---|---|
| Category   | Question   | Your Response |   |   |   |   |
|  |  | 4             | 3 | 2 | 1 | 0 |
| Points' calculation method   | 1. The points' calculation method is really a good one.  |               |   |   |   |   |
|  | 2. The firm should offer increasing the points gained when the spent amount increases  |               |   |   |   |   |
|  | 3. The firm should replace points with discounts   |               |   |   |   |   |
|  | 4. The expiry time limit on the accumulated points is a good policy  |               |   |   |   |   |
|  | 5. The firm should have no expiry time limit on the accumulated points   |               |   |   |   |   |
|  | 6. Putting a time limit on the points usage forces me to replace my points with any reward regardless of my needs                            |               |   |   |   |   |
|  | 7. Putting a time limit on the points usage results sometimes in losing points due to forgetting the deadline                                |               |   |   |   |   |
|  | 8. Putting a time limit on the points usage decreases my loyalty   |               |   |   |   |   |
|  | 9. The points granted to the frequent customers are enough   |               |   |   |   |   |
|  | 10. The firm should grant me extra points for being a frequent customer  |               |   |   |   |   |
|  | 11. The firm should distinguish the frequent customer from the infrequent one  |               |   |   |   |   |
| Reward granting policy   | 12. The rewards granting policy is good/or excellent one   |               |   |   |   |   |
|  | 13. The firm should offer the customer a set of rewards to select from and not always a fixed list or replace rewards with cash or discounts |               |   |   |   |   |
|  | 14. The firm should offer the customer with a high number of accumulated points with more reward sets to select from                         |               |   |   |   |   |
| Promotion Policy   | 15. The promotion policy is really a good one  |               |   |   |   |   |
|  | 16. The firm should offer the frequent customer more promotion offers than the occasional customer   |               |   |   |   |   |
|  | 17. The promotions offered for loyal customer should satisfy their needs   |               |   |   |   |   |
| Extra comments:  |  |               |   |   |   |   |

The mean ( $\mu$ ) for all answered questions is 2 and it is calculated by adding the weight on the five answers and dividing the result by 5; i.e.  $(4+3+2+1+0)/5$ .

The value of  $\mu$  is used to determine the level of customers' satisfaction:

If  $\mu > 2$ , the customers are satisfied;

If  $\mu < 2$ , the customers are not satisfied, and

If  $\mu = 2$ , the customers have an indifferent opinion.

When collecting feedback from the firm that implemented the proposed model and as shown in Table 2, the researchers found that the customers are not satisfied ( $\mu < 2$ ) with the point's calculation methods (questions 1, 4, and 9), rewards grants policy (question 12) and promotion policy (question 15) categories.

1. The points calculations methods is not a good one ( $\mu=1.50$  for question 1) because they were expecting to apply rules related to spent amount ranges (question 2); i.e. when the spent amount increases, the point gained should increase as well in order to retain more customer loyalty. Also, customers were expecting to replace accumulated points with discounts on the merchandise they wanted (question 3); not the offered one.
2. The time limit on points is not good ( $\mu=1.67$  for question 4). There should be no time limit on points (question 5). As long as companies put limits on the point's usage, this will reduce loyalty (questions 8) because it adds a pressure on customers to either use their points with any offered reward (question 6) that might not be useful at that time or causes the loss of points due to forgetting the deadlines (question 7).

**Table 2:** Accumulative summary to customers answers.

| Category                   | Question  | Scale |    |    |    |    | Average $\mu$ |
|----------------------------|---|-------|----|----|----|----|---------------|
|                            |   | 4     | 3  | 2  | 1  | 0  |               |
| Points' calculation method | 1. The points' calculation method is really a good one  | 10    | 13 | 8  | 55 | 29 | <u>1.50</u>   |
|                            | 2. The firm should offer increasing the points gained when the spent amount increases                             | 71    | 17 | 11 | 15 | 1  | 3.72          |
|                            | 3. The firm should replace points with discounts  | 62    | 21 | 20 | 6  | 6  | 3.57          |
|                            | 4. The expiry time limit on the accumulated points is a good policy   | 12    | 16 | 23 | 25 | 39 | <u>1.67</u>   |
|                            | 5. The firm should have no expiry time limit on the accumulated points  | 83    | 17 | 5  | 6  | 4  | 3.99          |
|                            | 6. Putting a time limit on the points usage forces me to replace my points with any reward regardless of my needs | 45    | 34 | 16 | 13 | 7  | 3.27          |
|                            | 7. Putting a time limit on the points usage results sometimes in losing points due to forgetting the deadline     | 51    | 39 | 11 | 9  | 5  | 3.52          |
|                            | 8. Putting a time limit on the points usage decreases my loyalty  | 24    | 21 | 41 | 17 | 12 | 2.58          |

### Development of a Customer Loyalty System

| Category               | Question   | Scale |    |    |    |    | Average $\mu$ |
|------------------------|--|-------|----|----|----|----|---------------|
|                        |  | 4     | 3  | 2  | 1  | 0  |               |
|                        | 9. The points granted to the frequent customers are enough   | 13    | 18 | 24 | 22 | 38 | <u>1.76</u>   |
|                        | 10. The firm should grant me extra points for being a frequent customer  | 33    | 35 | 18 | 16 | 13 | 2.89          |
|                        | 11. The firm should distinguish the frequent customer from the infrequent one  | 49    | 29 | 23 | 10 | 4  | 3.39          |
| Reward granting policy | 12. The rewards granting policy is good/or excellent one   | 9     | 14 | 31 | 29 | 32 | <u>1.69</u>   |
|                        | 13. The firm should offer the customer a set of rewards to select from and not always a fixed list or replace rewards with cash or discounts | 27    | 28 | 22 | 23 | 15 | 2.59          |
|                        | 14. The firm should offer the customer with a high number of accumulated points with more reward sets to select from                         | 42    | 36 | 21 | 9  | 7  | 3.27          |
| Promotion Policy       | 15. The promotion policy is really a good one  | 14    | 17 | 22 | 37 | 25 | <u>1.88</u>   |
|                        | 16. The firm should offer the frequent customer more promotion offers than the occasional customer   | 29    | 33 | 20 | 19 | 14 | 2.74          |
|                        | 17. The promotions offered for loyal customer should satisfy their needs   | 57    | 42 | 3  | 7  | 6  | 3.67          |

With respect to point's calculation method category, the customers mainly indicated that:

- The points granted to frequent customers are not enough ( $\mu=1.76$  for question 9). The model has no extra points for frequent customers (question 10). Frequent customers have no advantage over the occasional shopper (question 11); both types of customers are treated the same way in terms of getting points.

With respect to rewards granting policy category, the customers indicated that they don't like the rewards granting policy ( $\mu=1.69$  for question 12); the company applies fixed rewards always (question 13); they do not give many choices to customers to select from (question 14).

With respect to promotion policy category, the customers indicated that the promotion policy is not a good one ( $\mu=1.88$  for question 15). They have reservations about the promotions offered to them (question 16); these promotions are not enough for customer needs, and they were expecting more (question 17).

### Model Improvements

One way to increase customer's loyalty is by adding extra points on a yearly basis. This process depends upon a set of factors including: (1) The recorded number of customer visits either directly through a purchasing process or via browsing the web site, and (2) the number of years the customer has had as a committed relationship with the firm.

The *points' calculation policy* should increase the points based on the spent amounts and offer the customer the chance to replace the points with discounts. To gain more loyalty from customers, the firm should have no expiry limit on the accumulated points; i.e. keeping points accumulated as long as they wish (points has no expiry date!). Also, the firm should distinguish between frequent customers and the occasional one in terms of points.

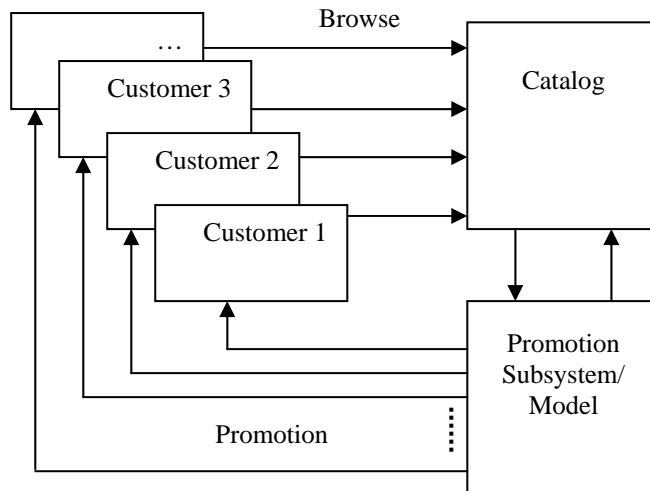
On the other hand, *the rewards granting policy* can be improved by allowing the customer to:

- 1- Freely choose between replacing points with cash or with gift(s), or getting a *suitable* discount. Suitable here means for both the firm and the customer as a compromise.
- 2- Freely choose any product as a gift depending on the accumulated points.
- 3- Map their points set as a set of gifts (Customizing their points and gifts).

The *promotion policy* can be improved by offering frequent customers more promotion chances than regular ones (customers). Also, the promotions offered to the loyal customers should be desirable to them.

The promotion policy can be also improved through:

1. Keeping statistical information about *each* customer independently to most frequently browsed products from the products' catalog. The block diagram shown in Figure 13 illustrates this process.



**Fig. 13:** Statistical Information for Each Customer.

2. Keeping statistical information about the *highest average for all* customer product hits on the web. The block diagram shown in Figure 14 illustrates this process.

## Development of a Customer Loyalty System

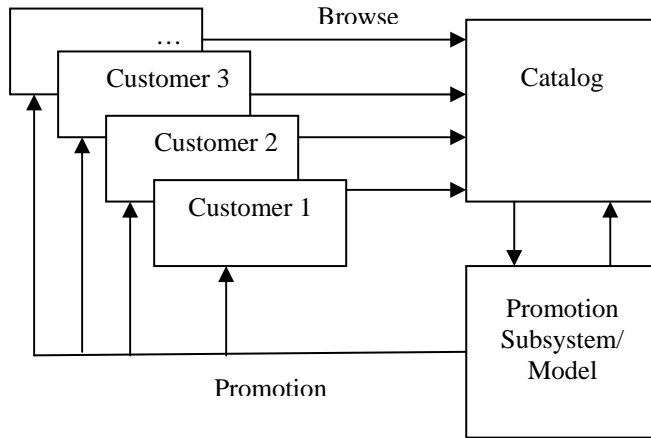


Fig. 14: Statistical Information for all customers.

### Conclusion

The development and implementation of a customized customer loyalty system has been introduced. The developed model addresses the challenges facing this type of loyalty system represented by the necessity of handling and managing a huge amount of valuable information concerning customers purchasing in retail stores.

The developed system has solved those challenges by implementing an easy to use yet powerful Graphical User Interface (GUI) to be interfaced with the store database to manage the process of purchasing, point's calculations, getting gifts and sending offers to customers.

Since customer satisfaction has a direct and positive impact on customer loyalty, this study has found that the loyalty of frequent customers can be enhanced by adding extra points on a yearly basis, offers customers the chance of replacing the points with discounts, and allowing the customer to freely choose between replacing points with cash or gift(s).

## كيفية تطوير نظام ولاء للمستهلك

رزق السيد، منعم زمزير، معتر السعيد ويوسف مجدلاوي

### ملخص

إن التطور الاقتصادي العالمي السريع زاد المنافسة في الأسواق وأدى هذا بدوره إلى الحاجة إلى تطوير أنظمة ولاء المستهلكين.

واحتاج هذا التنافس من المؤسسات تحقيق ميزة القدرة على التعامل مع البيئات ذات العلاقة بالمعلوماتية والأعمال الالكترونية وكذلك المحافظة على هذه الميزة. على المؤسسات القيام بخطوات إبداعية في استخدام تقنية المعلومات من أجل جذب المزيد من العملاء للشراء من هذه المؤسسات دون غيرها. ومن أفضل الأمثلة في هذا المجال أنظمة ولاء المستهلكين التي تقدمها الكثير من المؤسسات. إن نجاح هذه البرامج يعتمد وبشكل أساسي على الاحتفاظ بنشاط وحسابات العملاء، ربما الملايين منهم، والتي لا يمكن تطبيقها عمليا دون بناء نظام ولاء للمستهلك.

لقد قدمت هذه الورقة طريقة بناء نظام ولاء المستهلك الذي يستطيع القائم على المؤسسة من خلاله من حساب وإنشاء وطباعة التقارير عن أداء المؤسسة والعملاء وعن مدى النمو الذي تحققه هذه المؤسسة. ويستطيع من خلال ذلك القائمين على المؤسسة من التعلم واستخدام النظام المطور ودمجه مع أنظمة أعمال أخرى.

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## التقييد الأعلى وعدم وجود بعض الأقواس $(k, r)$ في $PG(2,31)$

ندى ياسين قاسم يحيى\* و هبة سهيل نجم عبدالله\*

تاريخ استلام البحث: 2010/5/18

تاريخ قبوله: 2010/12/5

### ملخص

ان التقييد الأعلى للأقواس  $(k, r)$  في المستوي الإسقاطي  $PG(2,31)$  لقيم  $3 \leq r \leq 30$  مجهولة القيم باستثناء  $r = 16, 17$  التي تم ايجادها في [4] و [7].

وقمنا في هذا البحث بايجاد تلك القيم المجهولة للأقواس  $(k, r)$  في المستوي الإسقاطي  $PG(2,31)$  لقيم  $3 \leq r \leq 30$  من خلال دراسة التقييد الأعلى كما في جدول (2.3)، واثبتنا عدم وجود بعض هذه الأقواس لقيم  $r < (q+3)/2$  و  $(q-1) <$  وحصلنا على المبرهناتين الاتيتين (1.3.8) و (1.3.9).

### مقدمة:

نرمز الى القيمة العظمى ل  $k$  بحيث يكون القوس  $(k, r)$  موجودا في المستوي الإسقاطي  $PG(2, q)$  بـ  $m_r(2, q)$ . كما نرمز الى القيمة الصغرى ل  $k$  بحيث يكون القوس  $(k, r)$  تاما في المستوي الإسقاطي  $PG(2, q)$  بـ  $t_r(2, q)$ .

المستوي الإسقاطي  $PG(2, q)$  المعروف على الحقل المنتهي  $GF(q)$  هو فضاء ذو بعد 2 يحوي  $q^2 + q + 1$  من النقاط و  $q^2 + q + 1$  من الخطوط وكل خط تقع عليه  $q+1$  من النقاط، وكل نقطة يمر خلالها  $q+1$  من الخطوط. كما أن أية نقطتين في المستوي الإسقاطي  $PG(2, q)$  يوجد خط واحد فقط يصل بينهما وكل خطين يلتقيان في نقطة واحدة فقط، وتوجد على الأقل أربع نقاط لا توجد ثلاثة منها على استقامة واحدة.

القوس  $(k, r)$  في المستوي الإسقاطي  $PG(2, q)$  هو مجموعة  $k$  من النقاط في المستوي بحيث يوجد  $r$  من النقاط على خط ولا يوجد  $r+1$  أو أكثر من تلك النقاط على خط، ويقال أن القوس  $(k, r)$  تاماً إن لم يكن محتوي في قوس  $(k+1, r)$ .

إن القيمة  $m_r(2, q)$  قد شغلت حيزاً كبيراً من دراسة وبحوث العلماء، ففي عام 1956 أثبت العالم  $(Barlotti)$  [4] أن  $m_r(2, q) \leq (r-1)q + r$  عندما  $gcd(r, q) = 1$ ،  $r > 2$ .

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\* قسم الرياضيات، كلية التربية، جامعة الموصل، الموصل، العراق.

المجاميع القالبية في المستوي الإسقاطي  $PG(2,q)$  عبارة عن مجموعة من النقاط ان كل خط في المستوي الإسقاطي  $PG(2,q)$  يقطع  $B$  بما لا يقل عن  $t$  من النقاط ويوجد خط يقطع  $B$  بـ  $t$  من النقاط بالضبط . يقال للمجاميع القالبية  $B$  أنها تافهة إذا احتوت على خط من الخطوط بكل نقاطه . وفيما يتعلق بهذه المجاميع فقد أعطى الباحثان (Hill) و (Mason) في عام 1981 [12] أمثلة عن المجاميع القالبية الثلاثية ذات حجم  $4q-1$  عندما  $q$  زوجي،  $4q$  عندما  $q$  فردي. وفي عام 1986 أثبت الباحث (Brune) [8] أن القيد الأدنى للمجموعة القالبية هو  $q + \sqrt{q} + 1$  في المستوي الإسقاطي. كما أثبت أن  $q + \sqrt{q} + 1$  هو القيد الأعلى للمجموعة القالبية الأصغرية في أي مستوي إسقاطي ذو رتبة  $q$ ، وفي عام 1987 درس المجاميع القالبية المزدوجة [9].

ملاحظة: عندما  $r=2$  فإن القوس  $(k,2)$  يعرف بالقوس  $k$ -

**(1.1.1) مبرهنة: [15]**

أي قوس  $k$ - في المستوي  $PG(2,q)$  يكون محتوي في قوس  $k+1$  عندما يكون  $q$  عدداً فردياً.

**(1.1.2) تعريف: [10]**

المجموعة  $B$  القالبية  $\{l,t\}$  في المستوي الإسقاطي  $PG(2,q)$  هي مجموعة  $l$  من النقاط ان كل خط في المستوي الإسقاطي  $PG(2,q)$  يقطع  $B$  بما لا يقل عن  $t$  من النقاط ويوجد خط يقطع  $B$  بـ  $t$  من النقاط بالضبط .

**(1.1.3) العلاقة بين المجموعة القالبية  $\{l,t\}$  والقوس  $(k,r)$ : [14]**

ان الاقواس  $(k,r)$  والمجاميع القالبية  $\{l,t\}$  تكون متممة الواحدة للآخرى في المستوي الإسقاطي  $PG(2,q)$  ان  $r+t = q+1$  . أي ان متممة المجموعة القالبية  $\{l,t\}$  هي مجموعة من النقاط التي تتقاطع مع جميع الخطوط على الأكثر بـ  $r$  من النقاط وهذه المجموعة تمثل القوس  $(k,r)$  . كما ان ايجاد أصغر مجموعة قالبية  $\{l,t\}$  يكافئ ايجاد اكبر قوس  $(k,r)$  في المستوي الإسقاطي  $PG(2,q)$  .

**(1.1.4) مبرهنة: [5]**

لتكن  $B$  مجموعة قالبية  $\{l,t\}$  في المستوي  $PG(2,p)$  و  $p > 3$  عدد أولي فان:

1. اذا كان  $t \leq (p-1)/2$ ، فان

$$|B| \geq \frac{(2t+1)(p+1)}{2}$$

2. اذا كان  $t \geq (p+1)/2$ ، فان  $|B| \geq (t+1)p$

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(1.1.5) مبرهنة:[6]

لتكن B مجموعة قابلية  $\{\ell, t\}$  في المستوي الاسقاطي PG(2,q) ، حيث أن  $|B| \geq t(q + \sqrt{q} + 1)$  : فان  $d \geq 2$  ،  $p > 3$  ،  $q = p^{2d}$  ، اذا كان  $t < \min(q^{1/6}, q^{1/4}/2)$

(1.1.6) مبرهنة:[6]

لتكن B مجموعة قابلية  $\{\ell, t\}$  في المستوي الاسقاطي PG(2,q) ، حيث ان  $|B| \geq t(q + \sqrt{q} + 1)$  : فان  $d \geq 2$  ،  $p = 2, 3$  ،  $q = p^{2d}$  ، اذا كان  $t < \min(2^{-1/3} q^{1/6}, q^{1/4}/2)$

(1.1.7) مبرهنة:[6]

لتكن B مجموعة قابلية  $\{\ell, t\}$  في المستوي الاسقاطي PG(2,q) ذات حجم  $t(q+1)+c$  . لتكن  $c_1 = 1$  و  $c_2 = c_3 = 2^{-1/3}$  ، فانه اذا كان  $q = p^2$  ، حيث  $p$  عدد أولي و  $t < q^{1/4}/2$  : فان  $|B| \geq t(q + \sqrt{q} + 1)$

من المبرهنات السابقة (1.1.4) ، (1.1.5) ، (1.1.6) و (1.1.7) قمنا بصياغة جدول بالقيود العليا لـ  $m_r(2, q)$  كالآتي

| n   | p عدد أولي<br>$q=p^h$                   | $m_r(2, q) \leq$  |
|---|---|---|
| $(p+3)/2$                                       | $p > 3$ فردي. $q=p$                     | $(p^2+p)/2+1$   |
| $n > p + 1 - \min(q^{1/6}, q^{1/4}/2)$          | $p > 3$ ، $q = p^{2d}$<br>$d \geq 2$    | $p^2 + p + 1 - \min(q^{1/6}, q^{1/4}/2) \times (p + \sqrt{p} + 1)$          |
| $n > p + 1 - \min(2^{-1/3} q^{1/6}, q^{1/4}/2)$ | $p = 2, 3$ ، $q = p^{2d}$<br>$d \geq 2$ | $p^2 + p + 1 - \min(2^{-1/3} q^{1/6}, q^{1/4}/2) \times (p + \sqrt{p} + 1)$ |
| $q+1-t$   | $q=p^2$                                 | $\sqrt{q} q^2 - (q+1)(t-1) - t$   |

ولغرض ايجاد القيد الادنى للمجموعة القابلية- $\{\ell, t\}$  في حالة B لا تحتوي على خط جئنا بالمبرهنة الآتية

(1.1.8) مبرهنة:[2]

لتكن B مجموعة قابلية  $\{\ell, t\}$  في المستوي PG(2,q) و B لا تحتوي على خط، فان:

$$|B| \geq tq + \sqrt{tq} + 1$$

ولغرض استنتاج المعادلات القياسية التي استخدمت في البند (1.3) وبرهانها المذكور في [3] جئنا بالمبرهنة الآتية

**(1.1.9) مبرهنة: [3]**

لتكن B مجموعة قابلية  $\_ \{\ell, t\}$  ذات حجم b في المستوي الإسقاطي PG (2, q) فان :

$$1. \sum_{i=0}^{q+1} r_i = q^2 + q + 1 ,$$

$$2. \sum_{i=1}^{q+1} i r_i = b(q + 1) ,$$

$$3. \sum_{i=2}^{q+1} i(i-1) r_i = b(b-1) ,$$

$$4. \sum_{i=1}^{q+1} v_i = q + 1 ,$$

$$5. \sum_{i=2}^{q+1} (i-1) v_i = b - 1 ,$$

$$6. \sum_{i=0}^q u_i = q + 1 ,$$

$$7. \sum_{i=1}^q i u_i = b ,$$

حيث  $T_i$  : يمثل العدد الكلي للقواطع - i للمجموعة B.

$v_i$  : يمثل العدد الكلي للقواطع - i للمجموعة B خلال النقطة P من نقاط المجموعة B .

$u_i$  : يمثل العدد الكلي للقواطع - i للمجموعة B خلال النقطة Q فسي  
PG(2, q)B .

**(1.1.10) تعريف: [14]**

يقال للمجموعة B القابلية  $\_ \{\ell, t\}$  انها أصغرية (Minimal) أو غير قابلة للتحليل عندما لا توجد مجموعة جزئية فعلية منها تشكل مجموعة قابلية - t .

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لغرض استنتاج العلاقة التالية واستخدامها في البند(1.3): اذا كانت B مجموعة قابلية اصغرية-t ذات حجم b فان  $b \leq tT_t$  جئنا بالمبرهنة الاتية

(1.1.11) مبرهنة:[1]

في المستوي الاسقاطي  $PG(2,q)$  ، القوس  $(k,r)$  ذو الرمز K يكون تاماً اذا وفقط اذا كانت  $PG(2, q)/K$  هي مجموعة قابلية أصغرية  $(q+1-r)$  .

البرهان:

( $\Leftarrow$ ) ليكن K قوساً تاماً ، واضح ان متممته  $B = PG(2, q) \setminus K$  هي مجموعة قابلية  $(q+1-r)$  تحوي  $q^2+q+1-k$  من النقاط . ان لم تكن B أصغرية فانه توجد في الاقل نقطة  $p \in B$  ، وان  $B \setminus \{p\}$  هي مجموعة قابلية  $(q+1-r)$  تحوي  $q^2+q-k$  من النقاط.

والان بالنظر الى المتممة لهذه المجموعة الاخيرة نجد انها تمثل القوس K مضافا اليه النقطة p بحيث يكون القوس  $(k+1,r)$  وهذا يناقض الفرض ، اذن B أصغرية.

( $\Rightarrow$ ) لتكن B مجموعة قابلية أصغرية  $(q+1-r)$  ذات حجم  $q^2+q+1-k$  من النقاط. واضح ان متممها هو القوس K . فلو كان K قوساً غير تام . فتوجد نقطة  $p \notin K$  بحيث ان  $K \cup \{p\}$  هو القوس  $(k+1, r)$  ولكن ظهر لنا ان متممة هذا القوس الجديد هي المجموعة القابلية  $(q+1-r)$  ذات حجم  $q^2+q-k$  وهي تمثل  $B \setminus \{p\}$  وهذا يناقض للفرض. ■

(1.1.12)تعريف [13] :

لتكن:  $F(x) = x^n - a_{n-1}x^{n-1} - \dots - a_0$  هي متعددة حدود أحادية (Monic) من الدرجة n فيمكن تعريف المصفوفة المرافقة (Companion Matrix) لـ F والتي يرمز لها C(F) بـ:

$$C(F) = \begin{bmatrix} 0 & 1 & 0 & \dots & \dots & \dots & 0 \\ 0 & 0 & 1 & \dots & \dots & \dots & 0 \\ \vdots & & & & & & \\ \vdots & & & & & & \\ 0 & 0 & 0 & \dots & \dots & \dots & 1 \\ a_0 & a_1 & a_2 & \dots & \dots & \dots & a_{n-1} \end{bmatrix}_{n \times n}$$

وهي مصفوفة ذات سعة  $n \times n$  .

(1.1.13) تعريف [13] :

إذا كان  $T$  هو إسقاط في المستوي  $PG(2,q)$  فإن  $T$  يسمى إسقاطاً دورياً (Cyclic Projectivity) إذا ولد جميع نقاط الفضاء في دائرة واحدة.

إذا كانت متعددة الحدود  $F(x)$  أحادية غير قابلة للتحليل مطلقاً (Absolute Irreducible) فإن المصفوفة المرافقة  $C(F)$  هي إسقاط دوراً للمستوي  $PG(2,q)$ .

(1.2) المستوي الإسقاطي  $PG(2,31)$  :

(1.2.1) المصفوفة المرافقة (Companion Matrix)

لتكن  $f(x) = x^3 - 4x^2 - x - 3$  متعددة حدود أحادية (Monic Polynomial) على الحقل المنتهي  $GF(31)$  وغير قابلة للتحليل مطلقاً (Absolutely irreducible) فإن المصفوفة

$$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 3 & 1 & 4 \end{bmatrix} T = f(x) \text{ لـ } f(x) \text{ هي: } T =$$

ومن خلال التعريفيين السابقين (1.1.12), (1.1.13) استطعنا اثبات ان  $T$  تمثل إسقاطاً دورياً (Cyclic Projectivity) على المستوي الإسقاطي  $PG(2,31)$  وهذا الإسقاط يجعل نقاط المستوي كلها تترتب بشكل دائرة واحدة فقط. وبناء على ما ذكر في المقدمة (1.1) فإن المستوي الإسقاطي  $PG(2,31)$  المعروف على الحقل المنتهي  $GF(31)$  هو فضاء ذو بعد 2- يحتوي على 993 نقطة وعلى 993 خط وكل خط يقع عليه 32 نقطة وكل نقطة يمر خلالها 32 خط. وان أي قوس-31 في المستوي  $PG(2,31)$  يكون محتوى في قوس-32 بحسب المبرهنة (1.1.1).

(1.2.2) نقاط الفضاء الإسقاطي  $PG(2,31)$  :

باختيار النقطة  $p_1 = (1\ 0\ 0)$  كنقطة ابتدائية في المستوي فإن باقي نقاط المستوي يمكن إيجادها بواسطة الضرب الأيمن للنقطة  $p_1$  بمصفوفة الإسقاط الدوار  $T$  وذلك حسب العلاقة الآتية:

$$p_i = p_{i-1} T, \forall_i = 2, 3, \dots, q^2 + q + 1$$

ويمثل الجدول (2.1) نقاط المستوي الإسقاطي  $PG(2,31)$ .

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جدول (2.1)

| i   | P <sub>i</sub> |    |    |
|-----|----------------|----|----|
| 0   | 1              | 0  | 0  |
| 1   | 0              | 1  | 0  |
| 2   | 0              | 0  | 1  |
| 3   | 1              | 21 | 22 |
| ⋮   |                |    |    |
| 991 | 1              | 5  | 17 |
| 992 | 1              | 4  | 30 |

(1.2.3) خطوط المستوي الاسقاطي PG(2,31):

خط المالانهاية سيكون هو الخط الأول في المستوي الاسقاطي PG(2,31) أي أن:

$$L_1 = \{0, 1, 21, 58, 85, 120, 135, 273, 304, 355, 430, 444, 470, 486, 531, 535, 553, 647, 653, 656, 681, 686, 694, 749, 760, 792, 846, 922, 924, 934, 941, 970\}$$

وعندما تكون احداثيات النقطة  $p_i = (x_i, y_i, 0)$  نحصل على الخط الاول من خطوط المستوي.

$$L_i = L_{i-1} T \quad , \quad \forall_i = 2, 3, \dots, q^2 + q + 1$$

والجدول (2.2) يوضح خطوط المستوي الاسقاطي PG(2,31).

جدول (2.2)

|                  |  |
|------------------|--|
| L <sub>1</sub>   | 0 , 1, 21, 58, 85, 120, 135, 273, 304 ,355 ,430, 444, 470, 486, 531, 535, 553, 647, 653, 656, 681, 686 ,694, 749, 760, 792, 846 ,922, 924, 934, 941, 970 |
| L <sub>2</sub>   | 1, 2, 22, 59, 86, 121, 136, 274 ,305 ,356, 431, 445, 471, 487, 532 ,536, 554, 648 654 657, 682, 687, 695, 750, 761 ,793, 847, 923,925, 935, 942, 971     |
| ⋮                |  |
| L <sub>993</sub> | 992, 0 ,20, 57, 84, 119, 134, 272,303, 354, 429, 443, 469, 485, 530 ,534, 552, 646, 652, 655, 680, 685, 693, 748, 759, 791,845, 921, 923, 933, 940, 969  |

يحيى وعبدالله

### (1.3) القيد الاعلى وعدم وجود بعض الأقواس $(k,r)$ في $PG(2,31)$

في هذا البند سنقوم بذكر بعض المبرهنات المهمة التي نستطيع من خلالها ايجاد القيد الاعلى للأقواس في المستوي الاسقاطي  $PG(2,31)$  ثم اثبات عدم وجود بعض تلك الأقواس في هذا المستوي لقيم  $(q-1) < r < (q+3)/2$ .

#### (1.3.1) تعريف [11]:

لتكن  $M$  مجموعة من النقاط في أي مستوى ، القاطع  $i$  هو خط يلتقي  $M$  بـ  $i$  من النقاط بالضبط، نعرف  $\tau_i$  على أنه عدد القواطع  $i$  للمجموعة  $M$ .

حيث أن  $\tau_i$  يحقق المعادلات الدايفونتينية الثلاثة الآتية والتي تعرف بالمعادلات القياسية :

1.  $\sum_{i=0}^{q+1} \tau_i = q^2 + q + 1$
2.  $\sum_{i=1}^{q+1} i \tau_i = b(q+1)$
3.  $\sum_{i=2}^{q+1} i(i-1) \tau_i = b(b-1)$

#### (1.3.2) مبرهنة [2, 10] :

ليكن  $K$  هو القوس  $(k,r)$  في  $PG(2,q)$ ، (حيث أن  $q$  أولي)

1- إذا كان  $r \leq (q+1)/2$  فإن  $m_r(2,q) \leq (r-1)q + 1$ .

2- إذا كان  $r \geq (q+3)/2$  فإن  $m_r(2,q) \leq (r-1)q + r - (q+3)/2$ .

#### (1.3.3) مبرهنة

ليكن  $K$  هو القوس  $(k,r)$  في  $PG(2,q)$  وأن  $r > (q+3)/2$ ،  $r = 17, 19, 23, 29$ ، فإن

$$m_r(2,q) \leq (r-1)q + r - (q+3)/2$$

البرهان: إيجاد أكبر قوس  $(r, (r-1)q + r - (q+1)/2)$  مكافئ لإيجاد  $B$  المجموعة القالبية  $\{q^2 + q + 1 - (r-1)q - r + (q+1)/2, q+1-r\}$ .

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$$\therefore \{q^2 + q + 1 - (r-1)q - r + (q+1)/2, q+1-r\} = \frac{(q+1)(2q+3-2r)}{2}$$

فان B ستكون المجموعة القالبيية  $\{(q+1)(2q+3-2r)/2, q+1-r\}$ .

(1.3.4) مبرهنة [10]:

لتكن B المجموعة القالبيية  $\{\ell, t\}$  في  $PG(2, q)$  ( $q$  أولي)

1- إذا كان  $q/2 < t < 3q$  ، فان  $\ell \geq n(q+1) + (q+1)/2$

2- اذا كان  $\ell = n(q+1) + (q+1)/2$  فان كل نقطة في B يمر خلالها  $(q+3)/2$  من الخطوط

بالضبط في حالة عدم وجود أي قاطع  $t$  ، ويمر خلالها  $(q-1)/2$  من الخطوط بالضبط في حالة

وجود  $t$  من القواطع، لذلك فان العدد الكلي للقواطع  $t$  سيكون  $\frac{\ell(q-1)}{2t}$ .

(1.3.5) مبرهنة [10, 2]:

لتكن B المجموعة القالبيية  $\{\ell, t\}$  في  $PG(2, q)$  والتي تحتوي على خط فانه إذا كان

$$|B| = \ell \geq q(t+1) \quad \text{فان} \quad (t-1, q) = 1 \text{ gcd}$$

(1.3.6) القيد الاعلى في المستوي الاسقاطي PG(2,31):-

في عام (1947) أثبت العالم Boss [7] أن القيمة العظمى  $m_2 = q+1$  عندما  $q$  فرديا

وأن  $m_2 = q+2$  عندما  $q$  زوجيا، ومن النتائج التي حصل عليها العالم Barlotti (1965) [4] و (1996)

Ball [2] أن  $m_r(2, q) = (r-1)q+1$  عندما  $r = (q+1)/2$  و  $r = (q+3)/2$ ، وأن  $q$  فرديا أوليا،

وكذلك من خلال المبرهنتين (1.3.2)، (1.3.3) استطعنا ايجاد القيد الاعلى للمستوي الاسقاطي

PG(2,31) كما هو مبين في الجدول الاتي:-

جدول (2.3)

| q<br>n | 11      | 13      | 16      | 17      | 19      | 23      | 25      | 27      | 29      | 31      |
|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 2      | 12      | 14      | 18      | 18      | 20      | 24      | 26      | 28      | 30      | 32      |
| 3      | 21      | 23      | 28-33   | 28-35   | 31-39   | 34-47   | 36-51   | 39-55   | 42-59   | 44-63   |
| 4      | 32-34   | 38-40   | 52      | 48-52   | 52-58   | 58-70   | 62-77   | 66-83   | 70-89   | 68-94   |
| 5      | 43-45   | 49-53   | 65      | 61-69   | 68-77   | 79-93   | 85-105  | 111     | 94-119  | 96-125  |
| 6      | 56      | 64-66   | 78-82   | 78-86   | 86-96   | 102-116 | 126-129 | 114-139 | 126-149 | 128-156 |
| 7      | 67      | 79      | 93-97   | 94-103  | 105-115 | 123-139 | 132-155 | ?-167   | 154-179 | 148-187 |
| 8      | 77-78   | 92      | 120     | 114-120 | 124-134 | 146-162 | ?-181   | ?-159   | 169-209 | 176-218 |
| 9      | 89-90   | 105     | 128-131 | 137     | 147-153 | 167-185 | ?-207   | ?-223   | 195-239 | 205-249 |
| 10     | 100-102 | 118-119 | 142-148 | 154     | 172     | 192-208 | ?-233   | ?-251   | 221-269 | 235-280 |
| 11     |         | 132-133 | 159-164 | 166-171 | 191     | 223-231 | ?-259   | ?-279   | 247-299 | 263-311 |
| 12     |         | 145-147 | 180-181 | 182-189 | 204-210 | 254-254 | ?-285   | ?-307   | 273-329 | 294-342 |
| 13     |         |         | 195-199 | 204-207 | 225-230 | 277     | 301-311 | 315-335 | 312-359 | 324-373 |
| 14     |         |         | 210-214 | 221-225 | 242-250 | 278-301 | 326-337 | 351-363 | 338-389 | 357-404 |
| 15     |         |         | 231     | 239-243 | 262-271 | 311-325 | ?-363   | 379-391 | 407-419 | 385-435 |
| 16     |         |         |         | 256-261 | 285-290 | 332-349 | ?-389   | ?-419   | 436-449 | 466     |
| 17     |         |         |         |         | 305-311 | 335-373 | ?-415   | ?-447   | ?-479   | 497     |
| 18     |         |         |         |         | 324-330 | 376-397 | ?-441   | 468-475 | 455-509 | 478-528 |
| 19     |         |         |         |         |         | 399-421 | ?-467   | ?-503   | ?-539   | 509-560 |
| 20     |         |         |         |         |         | 420-445 | 480-493 | ?-531   | ?-569   | 541-592 |
| 21     |         |         |         |         |         | 461-479 | 501-519 | ?-559   | 574-599 | 572-624 |
| 22     |         |         |         |         |         | 484-503 | 527-545 | ?-587   | 572-629 | 604-656 |
| 23     |         |         |         |         |         |         | 558-571 | ?-615   | ?-659   | 630-688 |
| 24     |         |         |         |         |         |         | 576-597 | 624-643 | 637-689 | 670-720 |
| 25     |         |         |         |         |         |         |         | 652-671 | 696-719 | 703-752 |
| 26     |         |         |         |         |         |         |         | 676-699 | 702-749 | 736-784 |
| 27     |         |         |         |         |         |         |         |         | 754-779 | 770-816 |
| 28     |         |         |         |         |         |         |         |         | 784-809 | 804-848 |
| 29     |         |         |         |         |         |         |         |         |         | 841-880 |
| 30     |         |         |         |         |         |         |         |         |         | 879-913 |

القيود الأعلى وعدم وجود بعض الأقواس  $(k, r)$  في  $PG(2,31)$

### (1.3.7) عدم وجود بعض الأقواس $(k, r)$ في $PG(2,31)$

سنقوم بإثبات عدم وجود الأقواس  $(k, r)$  لقيم  $(q-1) < r \leq (q+3)/2$  وذلك بتطبيق المبرهنتين (1.3.4), (1.3.5) على المستوي الإسقاطي  $PG(2,31)$  نحصل على المبرهنتين الآتيتين:-

#### (1.3.8) مبرهنة:

- 1- عدم وجود القوس  $(529,18)$  وأن  $m_{18}(2,31) \leq 528$ .
- 2- عدم وجود القوس  $(561,19)$  وأن  $m_{19}(2,31) \leq 560$ .
- 3- عدم وجود القوس  $(625,21)$  وأن  $m_{21}(2,31) \leq 624$ .
- 4- عدم وجود القوس  $(689,23)$  وأن  $m_{23}(2,31) \leq 688$ .
- 5- عدم وجود القوس  $(753,25)$  وأن  $m_{25}(2,31) \leq 752$ .

#### البرهان:

1- إيجاد أكبر قوس  $(529,18)$  مكافئ لإيجاد B المجموعة القالبية  $\{464,14\}$  مبرهنة (1.3.4) تتضمن على أن العدد الكلي للقواطع 14 هو  $\frac{232.15}{7}$  قاطع، ليس عدداً صحيحاً، وهذا تناقض .

الحالات 2,3,4,5 يتم برهانها بالطريقة نفسها في اعلاه ■

#### (1.3.9) مبرهنة:

- 1- عدم وجود القوس  $(593,20)$  وأن  $m_{20}(2,31) \leq 592$ .
- 2- عدم وجود القوس  $(657,22)$  وأن  $m_{22}(2,31) \leq 656$ .
- 3- عدم وجود القوس  $(721,24)$  وأن  $m_{24}(2,31) \leq 720$ .
- 4- عدم وجود القوس  $(785,26)$  وأن  $m_{26}(2,31) \leq 784$ .
- 5- عدم وجود القوس  $(817,27)$  وأن  $m_{27}(2,31) \leq 816$ .
- 6- عدم وجود القوس  $(849,28)$  وأن  $m_{28}(2,31) \leq 848$ .
- 7- عدم وجود القوس  $(881,29)$  وأن  $m_{29}(2,31) \leq 880$ .

البرهان:

1- إيجاد أكبر قوس (593,20) مكافئ لإيجاد B المجموعة القالبية {400,12} من مبرهنة (1.3.4) نحصل على أن العدد الكلي للقواطع 12 هو 500 قاطع.

نفرض أن  $n = 32$  (إذ أن  $n$  يمثل طول أطول قاطع للمجموعة القالبية B) فإن من مبرهنة (1.3.5)  $|B| \geq 403$  والتي لا تظهر عندما  $r > (q+3)/2$  كما هو موضح في العلاقة الرياضية الآتية:

$$\begin{aligned} q(q+1-r) + n &> q^2 + 2q - rq + 1 - r + (q+1)/2 \\ &= (q+1)(2q+3-2r)/2 = |B| \end{aligned}$$

أما إذا كان  $n > (q+3)/2 - r$  فإن B يجب أن تحتوي  $q(q+1-r) + n$  من النقاط على الأقل، وهذا تناقض حسب العلاقة الرياضية الآتية:

$$q(q+1-r) + n > q(q+1) - qr + 3(q+1)/2 - r = (q+1)(2q+3-2r)/2$$

الآن نفرض أن  $n_i = n$  إذ أن

$$n_i = 3\frac{q+1}{2} - r - i$$

$$i_1 = 1 + \frac{1}{4}\sqrt{2q^2 - 8q + 6} \quad \text{وأن } i_1 < i \leq \frac{(q-5)}{2}$$

من المبرهنة (1.3.4) العدد الكلي للقواطع t في المجموعة القالبية B هو

$$\chi = \frac{(q^2 - 1)(2q + 3 - 2r)}{4(q + 1 - r)} = \frac{\ell(q - 1)}{2t}$$

ولتكن M مجموعة من النقاط في المستوي وأن عدد القواطع  $i$  للمجموعة M هو

$$M_i = n_i \frac{q-1}{2} + (q+1-n_i)(q-i)$$

إذ أن  $M_i > \chi \dots (*)$

القيد الاعلى وعدم وجود بعض الاقواس-(k , r) في PG(2,31)

بما ان  $q = 31$  فان  $i_1 = 1 + \sqrt{105} = 11.24 \cong 11$  وكذلك  $\frac{(q-5)}{2} = 13$  لذلك فان المتراجحة (\*) تتحقق عندما  $i = 11, 12, 13$ ، وهكذا بالنسبة لبقية الحالات 2,3,4,5,6,7.

لكن عندما  $i = 13, r = 29$  فان  $n_{13} = 6$  و  $M_{13} = 558$  و  $\chi = 560$

أي أن المتراجحة (\*) لا تتحقق لذلك فان المعادلات القياسية للمجموعة B هي :

$$T_3 + T_4 + T_5 + T_6 = 993$$

$$3T_3 + 4T_4 + 5T_5 + 6T_6 = 3584$$

$$6T_3 + 12T_4 + 20T_5 + 30T_6 = 12432$$

الحل لهذه المنظومة بدلالة  $T_6$  هو

$$T_3 = 1294 - T_6, T_4 = -2239 + 3T_6, T_5 = 1422 - 3T_6$$

أي ان  $T_4 + T_5 = -817$  وهذا تناقض ايضا.

ملاحظة:-

في حالة  $r = 30$  لايمكننا البرهان بنفس الطريقة اعلاه وذلك لعدم تحقق العلاقة الرياضية

$$\begin{aligned} q(q+1-r) + n &> q^2 + 2q - rq + 1 - r + (q+1)/2 \\ &= (q+1)(2q+3-2r)/2 = |B| \end{aligned}$$

لذلك سيكون  $m_{30}(2,31) \leq 913$  حسب المبرهنة (1.3.2).

## On the Upper Bound and the Nonexistence of some (k ,r)-arcs in PG(2,31)

Nada Yassen Kasm Yahya and Hiba Suhil Najem Abd Allah

### Abstract

The upper bound for (k,r)-arcs in a projective plane PG (2,31) of  $3 \leq r \leq 30$  is un known except for  $r=16,17$  which is found in [4] and [7].

In this paper we finding unknown values for (k,r)-arcs in a projective plane PG(2,31) for  $3 \leq r \leq 10$  through studing the upper bound as in table (2.3), also we show that the non existence some of these arcs for the value  $(q+3)/2 < r < (q-1)$ , and we getting Theorems(1.3.8) and (1.3.9).

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## المعوقات المدركة لخدمات الحكومة الإلكترونية من وجهة نظر موظفي القطاع العام الأردني: دراسة ميدانية

رائد محمد العضايله\*

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تاريخ قبوله: 2011/7/10

### ملخص

تأتي هذه الدراسة للتعرف على التحديات التي تطوّر الخدمات الحكومية الإلكترونية ضمن البيئة الأردنية. وتحاول الدراسة تطوير نموذج لبيان هذه التحديات، ولتحقيق هذا الهدف، فقد تمّ توزيع استبانته على (484) مشارك تم اختيارهم باستخدام أسلوب العينة الملائمة، كل منهم مشارك في توفير الخدمات الحكومية الإلكترونية. وقد تضمن تحليل البيانات استخدام أسلوب تحليل العوامل لبيان مدى ملائمة الاستبانة المتبناة من معهد أكسفورد للإنترنت، كما تم استخدام أساليب الإحصاء الوصفي الحسابي للتعرف على التحديات التي تواجه تطبيق الخدمات الحكومية إلكترونياً من وجهة نظر المشاركين وترتيب هذه التحديات وفقاً لشيوعها ضمن نطاق المؤسسات العامة الأردنية. وتبين من التحليل أن هناك خمسة تحديات رئيسية تواجه الخدمات الحكومية الإلكترونية في إطار البيئة الأردنية وهي حسب إدراك المستجيبين لأهميتها: العوامل التكنولوجية، العوامل التنظيمية، العوامل الاقتصادية، العوامل المرتبطة بالسياسة العامة، والعوامل المرتبطة بالمهارات التقنية، وهذا يؤكد نموذج (PESTO) المقترح، وقد تم تقديم مناقشة شاملة وتفسير للنتائج بالإضافة إلى بعض التوصيات لمتخذي القرار في الحكومة الأردنية.

الكلمات المفتاحية: البيئة الإلكترونية، الخدمات الإلكترونية، المعوقات، الأردن، البلدان النامية.

### مقدمة

يمكن تعريف الحكومة الإلكترونية بأنها قدرة الإدارات والقطاعات الحكومية المختلفة على توفير وتقديم الخدمات والمعاملات والإجراءات الحكومية بوسائل إلكترونية للأفراد أو مؤسسات الأعمال أو للجهات والإدارات الحكومية ذاتها في إطار من الشفافية والوضوح وبمعنى أبسط تعني تقديم الخدمات الحكومية وإدارتها عبر شبكات المعلومات الدولية (الإنترنت) وغيره من الوسائط الإلكترونية الأخرى [43].

ومن المعتقد أن التكنولوجيا لوحدها لا تضمن تنفيذاً ناجحاً وانتشاراً للخدمات الإلكترونية [11]، فهناك عوامل أخرى تؤثر في استخدام الخدمات الإلكترونية وقد تشكل تحديات يجب التعامل معها لضمان نجاح هذا الاستخدام. فالتحول من الخدمات التقليدية إلى الخدمات إلكترونية يواجه مجموعة من التحديات التي يعرفها اينون ودوتن [14] على أنها مجموعة من العوامل الحقيقية أو المدركة التي تمتلك القدرة على التأثير في نجاح أو فشل برامج الحكومات الإلكترونية لأنها:

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\* قسم نظم المعلومات الإدارية، كلية إدارة الأعمال، جامعة مؤتة، معان، الأردن.

## العضايله

1. تعترض سبيل الطلب على الخدمات الالكترونية عن طريق العمل كعائق أمام مستخدمي خدمات الحكومة الإلكترونية.
2. تعيق سبيل العرض للخدمات الالكترونية عن طريق العمل كعائق أمام مؤسسات القطاع العام لتقديم خدمات الحكومة الإلكترونية.
3. تحدّ من الجهود الرامية لإعادة ترتيب سبل الوصول إلى المعلومات والعاملين والخدمات العامة من خلال تكنولوجيا المعلومات والاتصال.

إن التعريف السابق يؤلف الفئات المختلفة التي تشكل الحواجز القائمة أمام التنفيذ الفاعل وتبني الخدمات الإلكترونية. وهي تتلخص بالقيود القانونية والاجتماعية أو الثقافية والتقنية والتنظيمية والتي يمكن أن تحدّ من دعم الخدمات الإلكترونية، ومع ذلك ورغم أن هذا التعريف شامل ومفصل، إلا أنه لم يتطرق للحواجز المالية التي تعتبر قيوداً رئيسية لتنفيذ وتبني الخدمات الإلكترونية [11, 23]، ويحدّد لـ [24] حواجز الخدمات الإلكترونية عن طريق تقسيمها إلى حواجز داخلية وخارجية؛ فالحواجز الخارجية تشتمل على: الحواجز التشريعية والتنظيمية وحواجز الميزانية والتقسيم الرقمي في حين أن الحواجز الداخلية ترتبط بشكل وثيق مع الحواجز التنظيمية وتتضمن نقص التعاون والتنسيق ومهارات الموظفين والشراكة بين القطاعين العام والخاص والقيادة والمراقبة والتقييم.

وعلى الرغم من أن هذا التوضيح للحواجز يساعد على فهمها بشكل أفضل إلا أن هناك حاجة لدراسة العلاقة بين هذه الحواجز وأصحاب المصالح الرئيسيين فيما يتعلق بتقديم الخدمات الالكترونية. إن الأدب المتوافر حول عقبات الخدمات الإلكترونية تميل نحو توضيح المعنى الكلي لهذه الحواجز من خلال تعريف الفئات المختلفة التي تؤلف ما هو معروف باسم الحواجز أو التحديات أو الصعوبات، والقسم التالي يقدم مراجعة للأدبيات المتعلقة بموضوع الدراسة.

### معوقات الخدمة الإلكترونية:

#### المعوقات الاقتصادية:

الحواجز المالية يمكن أن تعيق تقدّم الخدمات الإلكترونية من كلتا الناحيتين العرض والطلب، ويؤكد إبراهيم والإيراني، [11] على أهمية الحواجز المالية لكل من المزودين والمستخدمين أو المستهلكين للخدمات الالكترونية. وأشاروا إلى انه من ناحية المزودين فهناك حاجة لمصادر كافية لتغطية كلفة تبني وتحويل خدماتهم، في حين أن المستخدمين لهذه الخدمات يمكن أن تعيقهم الحواجز المالية عندما تمنعهم من الحصول على خدمات شبكة تبادل المعلومات (الانترنت)، وأشار أرمستون [12] إلى أن تحويل الخدمات التقليدية إلى خدمات إلكترونية هو تحويل يتطلب إنفاق ضخم وفوري للتكاليف الثابتة، ويلخص أهمية العوائق المالية في إطار مؤسسات القطاع العام بالتأكيد على أن "الألم فوري في حين أن المكسب بعيد المنال" وهذا يعني أن الحاجة إلى التمويل الضخم لتحويل وتطوير الخدمات التقليدية إلى خدمات إلكترونية سيتسبب في إيجاد عبء فوري على ميزانيات الحكومات ولكنه سيخفض تكاليف تقديم الخدمات الحكومية على المدى البعيد، ويقول هيكس [16] أن غالبية هذه التكاليف غير ملموسة وإن الوعي بوجودها سيؤدي إلى التعامل معها بكفاءة أو أنه سيقوم بتخفيض أو إنهاء وجودها من الواقع كحواجز

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ربما تؤدي إلى فشل جزئي أو كلي لتوفير الخدمات الإلكترونية، إن التكاليف التي قام ادمستون وهيكس [16,12] بمناقشتها تبين بعض أنواع التكاليف المرتبطة بتقديم الخدمات الإلكترونية وتشمل ميزانيات لدفع تكاليف برامج الحاسوب وأدواتها المادية المختلفة ولتدريب موظفي القطاع العام، ومراكز تكنولوجيا المعلومات والاتصالات (ICT) وشبكات الأعمال والبنية التحتية.

ويشير نورس وزملائه [26] إلى أن المشكلة فيما يتعلق بالقطاع العام تكمن في اعتماده على الميزانية الحكومية، والتي قد تؤدي إلى نقص التمويل اللازم من أجل تطوير الخدمات الإلكترونية. ويعزز لام [23] هذه المسألة بقوله إن الطريقة في تدبر التمويل اللازم لمبادرات الخدمات الإلكترونية يمكن أن تكون عائقاً وخصوصاً عندما يتم منح التمويل على مراحل يعتمد كل منها على إنجازات المراحل السابقة، أما إبراهيم والإيراني [11] فقد حددا متطلبات الإنفاق الرئيسية المتوقعة التي تواجهها الحكومة في محاولتها التحول للخدمات الإلكترونية لتشمل تكاليف الخبرة والتركيب والتشغيل والصيانة لنظام الحكومة الإلكترونية، وتكاليف تطوير النظام والتدريب، وعدم توفر التمويل الكافي يمكن أن يبطل تنفيذ الحكومة الإلكترونية [39]، ومع ذلك فإن صعوبة ضمان تدفق المصادر المالية لتطوير الخدمات الإلكترونية يعود إلى صعوبة التقدير الواضح للفوائد الناتجة عن الاستثمار في الأنظمة والمعدات وخصوصاً عندما تكون الفوائد من النوع طويل الأجل لذلك يصعب تحديدها بسبب إنها غير محسوسة أو لحقيقة كونها ترتبط بالمستقبل [27].

إن العائق الذي ربما يكون أكثر أهمية هو أنه حتى وأن استطاعت الحكومات التغلب على التكلفة العالية لتنفيذ وتقديم الخدمات الإلكترونية فيبقى عليها التأكد أن مواطنيها يمكنهم الحصول على هذه الخدمات الإلكترونية، وهذه المسألة في غاية الأهمية عند الحديث عن البلدان النامية حيث الدخل المتدني يقابله ارتفاع تكلفة تكنولوجيا المعلومات (أجهزة وبرامج الحاسوب) والاتصالات الخاصة بشبكة تبادل المعلومات (الإنترنت) [11,1]، وهذه الحقيقة تؤدي إلى حرمان المستخدمين من حقهم في الاستفادة من الخدمات الإلكترونية المتاحة بسبب عدم قدرتهم على تحمل تكاليف شراء التقنيات اللازمة أو الدفع مقابل استخدام شبكات تبادل المعلومات (الإنترنت).

#### المعوقات المتعلقة بالمهارات التقنية:

أن ضعف المهارات التقنية يبقى عقبة أمام قبول واستخدام الخدمة الإلكترونية، وهي منطقياً ذات علاقة متشابكة مع العقبات المالية، ويؤكد هو [18] أن الخلفية الاجتماعية الثقافية تؤثر على المدى الذي يُستخدم فيه المواطنين الإنترنت والحاسوب.

ولتوضيح هذا يتوجب علينا أن ندرك أن هناك عادة مجموعات معينة من المجتمعات الموصوفة بأنها "مجتمعات مسرفة في الاستخدام" الخاص بالخدمات الحكومية التقليدية؛ وهم أناس على درجة متدنية من حيث الدخل من المسنين والمصابين بإعاقات، ومع ذلك، فإن هذه المجموعات لا تمتلك عادة طرق وصول للخدمات الإلكترونية بسبب نقص الموارد المالية والمهارات التقنية والذي يؤدي إلى ما يعرف بالتقسيم الرقمي (Digital divide) وهو مصطلح يعبر عن الفجوة القائمة بين "امتلاك التكنولوجيا" و"عدم امتلاكها" [34]، ويؤكد لو [24] أن استبعاد مجموعات معينة بسبب التقسيم الرقمي يحرمهم من الحصول

## العضايله

على جودة الخدمة من خلال الخدمات الإلكترونية المباشرة، ويرى لو أن الحكومات تستطيع بل يجب أن تقدم الخدمات لمواطنيها من خلال قنوات أخرى، ويقول بيترسون وزملائه [29] أنه على الرغم من أن الوصول إلى تكنولوجيا المعلومات والاتصالات هو مطلب أساسي للمشاركة باستخدام الخدمات الإلكترونية إلا أن هذا ليس كل ما في الأمر بل إن هناك حاجة لامتلاك الدافعية والمهارات لاستخدام تلك التكنولوجيا.

### المعوقات التكنولوجية:

يمكن للعقبات التكنولوجية أن تكون معوقات عملية رئيسة أمام أنظمة الحكومة الإلكترونية [14]، والحاجز التكنولوجي الرئيس وفقاً إلى [11,23,14] هو عدم القدرة على تبادل واستخدام المعلومات بين المؤسسات الحكومية المختلفة بسبب صعوبة الربط التكنولوجي بين هذه المؤسسات الكبيرة من حيث الحجم والعدد، وهذا يُشكّل عائقاً أمام اندماج الخدمات المختلفة مما يحد من كفاءة وفعالية الخدمات العامة، كما أن تباين المستوى التقني والبنية التحتية التقنية بين المؤسسات الحكومية المختلفة يضعف من إمكانية الربط الإلكتروني بين هذه المؤسسات لغياب السياسات والمعايير العامة وهو ما يعرف "بجزر الأتمتة" [23] الذي يقف في طريق تحسين جودة الخدمة الإلكترونية من خلال الدمج.

كما أن العوائق التكنولوجية قد تتعلق ببعض عناصر التصميم للخدمات الإلكترونية وخاصة تلك المتعلقة بواجهة المستخدم التي ربما لا تقدم المعلومات والمحتوى بطريقة تناسب الجميع حسب قدراتهم، وقد يؤدي ذلك إلى ابتعاد أو هجرة كاملة لاستخدام الخدمات الإلكترونية.

### المعوقات المتعلقة بالسياسة العامة:

وتشمل الإطار القانوني المناسب والأنظمة والتعليمات التي تسهل تقديم وتفعيل الخدمات الإلكترونية في بيئة إلكترونية آمنة، ويسبب نقص إطار العمل هذا وجود حواجز محتملة على مستويات مختلفة [39]، فالقوانين الناقصة التي لا تستطيع حماية أثبات الهوية وخصوصية الوثائق الإلكترونية والمعلومات الشخصية تقف في طريق تطوير الخدمات الإلكترونية [39,24]، حيث أن الضعف في هذه النواحي يعتبر عائق أمام كسب ثقة المستخدمين للخدمات الإلكترونية، ويشير إبراهيم والإيراني [11] إلى أن الكثير من المستخدمين لا يسعون حقاً لاستخدام الخدمات الإلكترونية بسبب نقص الثقة بهذا الشكل من الخدمات وخصوصاً عندما يتعلق الأمر بعرض مسائل حساسة مثل المعلومات الشخصية والقيام بتحويلات مالية والتي يحتمل أن تكون مع أكثر من مؤسسة حكومية، ويؤكد اينون ودوتن [14] هذا عن طريق التنويه بأنه في الوقت الذي يكتسب فيه استخدام الانترنت والتجارة الإلكترونية في القطاع الخاص ثقة عامة ما بين المستخدمين فإن الخدمات الإلكترونية الحكومية ترتبط بالمزيد من القلق فيما يتعلق بالثقة، وتبعاً لذلك، فإن هذا قد يؤدي إلى أزمة الثقة بين حاجة الحكومات لجمع البيانات حول الأفراد لتقديم الخدمات ومخاوف المستخدمين من إساءة استخدام معلوماتهم الشخصية.

وبناءً على ما سبق فإن الحاجة ماسة لأخذ عنصري الخصوصية والأمان بعين الاعتبار من المراحل الأولى لمشروع تقديم الخدمات الإلكترونية لتجنب فقدان المستخدمين للثقة في الخدمات الإلكترونية، وعلاوة على ذلك، فيمكن للأنظمة المتعددة المختلفة بين المؤسسات الحكومية أن تعيق تقدم مشروع الحكومة الإلكترونية، وهذا يحدث عندما تكون هناك مؤسسات متعددة ذات تشريعات مختلفة لتوفير الخدمة

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الإلكترونية مما قد يؤخر أو ربما يمنع توفير الخدمة الإلكترونية، وإضافة إلى ذلك، فهناك مسألة قانونية تتعلق بمن يتحمل المسؤولية إن حدث خطأ ما بسبب فشل تقني وهي مسألة قانونية أخرى لم تحل بعد، والمجازفة القانونية يمكن أن تظهر أيضاً عندما يكون هناك انتهاك لحقوق الملكية الفكرية أو الخصوصية أو السرية [24,39,14].

#### المعوقات التنظيمية:

تمثل مؤسسات القطاع العام وحدات بيروقراطية هائلة أو كما أشار إليها لام [23] على أنها أرث العمل الحكومي وتطبيقاته على مر الكثير من السنوات، فالتحول نحو تقديم الخدمات الإلكترونية لتحل محل الخدمات التقليدية يمكن أن يقاوم بواسطة العاملين بالخدمة المدنية والذين ربما يكونوا متخوفين من تأثيرات هذا التغيير ونتائجه، أن الخوف من فقدان الوظيفة أو امتيازاتها هو أحد المعوقات الإدارية الذي يمنع الترحيب بتقديم الخدمات الإلكترونية إلى القطاع العام [37,20]، ويسمي لام [23] مشاعر المستخدمين عند تقديم الخدمات الإلكترونية لمؤسساتهم بأنها "صدمة ثقافية" لأنه لا يوجد هناك ما يكفي من الوعي بالمفهوم بحيث يجد الموظفين صعوبة أحياناً في مسايرة التغيرات السريعة التي تحدث في مؤسساتهم.

ولذلك، فإن القيادة الحكومية القوية يتوجب أن تؤيد هذا التحول في الإرث التقليدي للخدمات [11]، وزيادة على ذلك، فإن دور القيادة هو دور حاسم لتطوير ونشر رؤيا الحكومة الإلكترونية وقيادة التحول وتعزيز وتنسيق المبادرات وتقديم الحوافز للمؤسسات المشاركة في الخدمات الإلكترونية [44]، ويشير فاسيلاكس وزملائه [39] إلى ما سموه "السياسات المعقدة" حيث أن سياسات المؤسسات الحكومية موجهة نحو "الراحة المؤسسية" لا إلى "خدمة المواطن"، وهذا يعني أن ضعف الاندماج والتنسيق بين المؤسسات الحكومية المختلفة يجبر المستخدم على ملء عدد هائل من الوثائق لمؤسسات مختلفة بنفس المعلومات، كما يشير إبراهيم والإيراني [11] إلى هذا النقص أو رداءة الاتصال والتنسيق بين المؤسسات العامة، لذلك تعتبر الحواجز التنظيمية عائق رئيسية أمام تبني ونشر الخدمات الإلكترونية.

ويتوجب أن تبني الخطط والاستراتيجيات بتفكير يتعدى مجرد تقديم التكنولوجيا إلى المؤسسة الحكومية إلى تغيير بيئة الإدارة واتجاهاتها نحو مبادرات الحكومة الإلكترونية وهذه من بين الطرق التي تقلل أثر العوائق التنظيمية [23,39].

ومن الجدير أن نلاحظ حقيقة أن العوائق السابقة تنزع إلى التشابك والتداخل مع بعضها البعض، فعلى سبيل المثال، فإن عدم القدرة على توفير الخدمات الإلكترونية يعود إلى الدخل المتدني وهو حاجز مالي يمكن أن يؤدي إلى تقسيم رقمي يقود إلى ضعف المهارات، وزيادة على ذلك، فيمكن أحياناً تقسيم الحاجز تحت فئتين، فعلى سبيل المثال فإن الخصوصية والأمان يمكن أن تتصل بعوائق المهارة والعوائق التقنية أو تلك المتعلقة بالسياسة العامة. ومع ذلك، فإنها جميعاً تبقى عوائق رئيسية تعيق تنفيذ وتطوير الخدمات الإلكترونية.

## معوقات الخدمات الإلكترونية في الدول النامية:

الكثير من الدراسات تناولت معوقات تنفيذ الحكومة الإلكترونية في الدول النامية والتي ترتبط بشكل أساسي مع البيئة الاجتماعية والاقتصادية والسياسية حيث التصور حول البلدان النامية يرتبط عادة مع الاقتصاد المتردي والفساد والبيروقراطية والجهل... الخ، ومن الواضح أن جميع هذه الأمور هي عوامل رئيسية في منع تطوير وتفعيل الخدمة الإلكترونية، ويرى ندو [25] أن تعدد أبعاد الخدمات الحكومية الإلكترونية وتعقيدها ربما يفرض مجموعة متنوعة وواسعة من التحديات أمام تطويرها وإدارتها، ويعتبر نقص البنية التحتية التقنية الملائمة والكاملة وفقاً لرأي ندو عائقاً أساسياً، كما ترى أن تفعيل الخدمات الإلكترونية ليس مسألة تكنولوجيا فحسب بل هي إنسانية أيضاً حيث يتوجب على الناس امتلاك المعرفة الخاصة بتكنولوجيا المعلومات والاتصالات كما تتطلب الحرية والرغبة في الوصول إلى المعلومات والخدمات الإلكترونية، ويعتقد باسو [6] أن تطوير الحكومة الإلكترونية يتطلب توفر البنية التحتية التقنية القادرة على دعم وتمكين تنفيذ الحكومة الإلكترونية، ومع ذلك فإنه يدعي بأن الكثير من الدول النامية لا تمتلك البنية التحتية اللازمة لنشر خدمات الحكومة الإلكترونية.

ويؤكد تشن وزملانه [9] ذلك حيث يرون أن حجم وقدرات البنية التحتية التقنية بين الدول المتقدمة والنامية تختلف بشكل كبير، وهذا بدوره يؤثر على الوصول إلى الإنترنت والهاتف من أجل الاتصالات، ففي حين تتوفر في البلدان المتقدمة طرق وصول سهلة للإنترنت والهاتف فإن هناك بنية تحتية ناقصة في البلدان النامية وهذه نتيجة طبيعية للظروف الاقتصادية أو السياسية المتردية والتي تجعل موضوع تقديم طرق الوصول الإلكترونية للجميع غاية في الصعوبة.

كما ترى الكثير من الدراسات أن العوائق التنظيمية تعتبر حاجزاً مهماً أمام تنفيذ ناجح للخدمات الإلكترونية في الدول النامية، فالهرمية هي ميزة تقليدية للمؤسسات العامة في البلدان النامية [15] أن تقديم مبادرات الخدمات الإلكترونية في مثل هذه المؤسسات يعني اقتساماً للمعلومات والمعرفة الذي عادة ما يواجه مقاومة من قبل موظفي الحكومة، وتزعم ندو [25] أن مقاومة التغيير من قبل موظفي الحكومة هو أكبر حاجز أمام التغيير الناجح ضمن نطاق المؤسسات العامة.

وبالإضافة إلى ذلك، فإن ندرة الموارد اللازمة لتحويل مبادرات الحكومة الإلكترونية هي عامل آخر يعوق تنفيذ الخدمات الإلكترونية في البلدان النامية [41,17]، وتبعاً لوصف هيكس [16] فإن المسألة الرئيسية التي تؤدي إلى ذلك هي نقص الوعي بالتكاليف المحسوسة والحاجة لإعطاء الأولوية للمتطلبات الأكثر إلحاحاً مثل شق الطرق وبناء المدارس وخصوصاً عند المنافسة على الموارد النادرة، ويؤكد سالم [32] أن الدور المهيمن للقطاع العام في النشاط الاقتصادي والصراعات السياسية التي تستنفذ الكثير من المصادر العامة والتي تكون موجهة غالباً إلى الأنفاق العسكري والتهديدات الأمنية من الإرهاب والحروب وكذلك الصفقات المدفوعة سياسياً أو تجارياً أو تكنولوجيا جمعياً تؤدي إلى مجازفات استثمارية مدركة عالية واستنزاف العقول وتذبذب حركة رأس المال، وتبعاً لذلك فسيكون من الأكثر صعوبة تقديم خدمات إلكترونية ناجحة، وتعزيزاً لهذا، يقول تشن وزملانه [9] أنه في الوقت الذي تمتلك فيه بعض الدول النامية اقتصاداً مستقراً وأنظمة حكومية مستقرة فإن غالبيتها اكتسب استقلاله مؤخراً أو لا زال في حالة حرب،

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وهذه هي الحالة في الشرق الأوسط وآسيا (العراق، أفغانستان) وهذا يضعف البنية الاقتصادية والحكومية لهذه البلدان وما حولها من البلدان، كما يؤكد سيدي وبارد [30] على أن النمو الاقتصادي البطيء تسبب في معدلات بطيئة من التقدم التكنولوجي والابتكار والذي يؤدي بدوره إلى تقسيم رقمي ضخم من حيث تكنولوجيات المعلومات والاتصالات.

وزيادة على ذلك فإن باسو [6] يشير إلى أهمية وجود أطار عمل قانوني لتوجيه الجانب التشريعي للحكومة الإلكترونية في البلدان النامية، فالقوانين الجديدة التي تتناول الخدمات الإلكترونية يجب أن يتم تبنيها وتميرها، ويعتبر ذلك ضرورياً لتعزيز الرؤيا التقنية الاجتماعية.

من خلال مراجعة الأدبيات السابقة المتعلقة بحواجز الخدمات الإلكترونية في كلا البلدان المتقدمة والنامية فيبدو أن الكثير من الحواجز مشتركة، ويأتي هذا البحث كمحاولة لتحديد المعوقات التي تواجه الخدمات الحكومية الإلكترونية من وجهة نظر العاملين في القطاع العام، ويزعم زانغ وزملائه [40] أن تقييم تلك المعوقات قد يتباين بسبب المستويات المختلفة للمشاركة في صنع القرار، والدراسة الحالية تدرك أن المزودين (موظفي القطاع العام) والمستخدمين (المواطنين) للخدمات الإلكترونية عادة ما يظهروا أهدافاً مختلفة وإن المزودين ربما يمتلكون تأثير أكبر في تقرير اتجاه وعملية تطوير الخدمات الإلكترونية لأنهم مشاركون أكثر في عمليات صنع القرار، لذلك فمن المهم أن دراسة مدركاتهم للعوائق التي تواجههم في تقديم الخدمات الإلكترونية.

### أهداف الدراسة:

تأتي هذه الدراسة لتقديم نموذجاً لبيان المعوقات المدركة لتقديم الخدمات الحكومية الإلكترونية من وجهة نظر العاملين في مؤسسات القطاع العام، وتقتصر الدراسة الحالية إطار عمل يشتمل على هذه المعوقات يشابه نموذج تحليل (PEST)، والذي هو ببساطة إطار عمل يصنف المؤثرات البيئية على أنها قوى سياسية واقتصادية واجتماعية وتكنولوجية يحتمل أن تؤثر على العرض والطلب [21,22]. وقد تم إضافة المعوقات التنظيمية حيث تفترض هذه الدراسة بأن المعوقات التنظيمية يمكن أن يؤثر بقوة في تبني الخدمات الإلكترونية في القطاع العام، وتبعاً لذلك فإن النموذج المقترح للتحليل يصبح (PESTO) والذي يشير إلى تشير إلى القوى السياسية والاقتصادية والاجتماعية والتكنولوجية والتنظيمية، وبناءً على ما سبق فإن هذه الدراسة تهدف إلى:

- تقديم إطار نظري ملائم لبيان المعوقات المحتملة التي تواجه تقديم وتفعيل الخدمات الحكومية الإلكترونية.
- تحديد المعوقات التي تواجه تقديم الخدمة الحكومية الإلكترونية من وجهة نظر العاملين في القطاع العام الأردني.
- ترتيب المعوقات أعلاه حسب أهميتها النسبية في إطار البيئة الأردنية.

## منهجية الدراسة

اعتمدت الدراسة الحالية أسلوب البحث الميداني، حيث تم إجراء المسح المكتبي والإطلاع على الدراسات والبحوث النظرية والميدانية، لأجل بلورة الأساس الذي يقوم عليه الإطار النظري والفكري لمتغيرات الدراسة، والوقوف عند أهم الدراسات السابقة ذات الصلة بموضوع الدراسة الحالية، أما على صعيد البحث الميداني التحليلي فقد تم إجراء المسح الاستطلاعي، وتحليل كافة البيانات المتجمعة من خلال الإجابة على فقرات الاستبانة واستخدام الطرق الإحصائية المناسبة لتحقيق أهداف الدراسة.

تكون مجتمع الدراسة من كافة العاملين في مراكز الوزارات الأردنية وقد تم استخدام أسلوب العينة الملائمة حيث تم توزيع 500 استبانة على عينه من العاملين في مراكز الوزارات الأردنية وهم مشاركون في توفير الخدمات الحكومية الإلكترونية، ويرى الباحث ومن خلال التوزيع الميداني للإستبانة بان المبحوثين تتوفر لديهم المعرفة الكافية بموضوع الدراسة، وتم استعادة 484 استبانة خضعت جميعها للتحليل وبنسبة استرجاع بلغت 96.8%، وقد تم استخدام مقياس Likert الخماسي حيث تراوحت إجابات المبحوثين من 1 إلى 5 (5=موافق بشده و1=غير موافق بشده).

واعتماداً على المسح المكتبي والإطلاع على الدراسات السابقة المتعلقة بموضوع الدراسة تم بناء استبانته بغرض جمع البيانات اللازمة لتحقيق أهداف الدراسة، وتكونت الاستبانة من جزئين الأول يغطي المتغيرات الديموغرافية والشخصية، أما الجزء الثاني فتكون من 30 فقره تغطي متغيرات الدراسة الخمسة، وقد تم استخدام أسلوب تحليل العوامل للتأكد من مدى ملائمة فقرات الاستبانة التي تم تبنيها من معهد أوكسفورد للإنترنت لقياس متغيرات الدراسة، وقد اثبت تحليل العوامل ملائمة فقرات الاستبانة لقياس متغيرات الدراسة وذلك من خلال قيمة معامل التحميل التي تجاوزت 0.20 لجميع فقرات الاستبانة [8]، وقد تم تحليل البيانات اعتماداً على الرزمة الإحصائية للعلوم الاجتماعية (SPSS)، حيث تم استخدام أساليب الإحصاء الوصفي وتحليل العوامل بالإضافة معامل كرونباخ ألفا (Cronbach Alpha) للاتساق الداخلي للتحقق من الانسجام بين فقرات الاستبانة حيث بلغت قيمته (0.86) وتعد هذه النسبة مقبولة لغايات البحث العلمي [8].

## تحليل البيانات:

### تحليل العوامل:

تحليل العامل هو أسلوب إحصائي يستخدم لتحديد ما إذ كانت مجموعات المؤشرات تنزع لتشكيل مجموعات مميزة يشار إليها بأنها عوامل، وأحياناً تستخدم أيضاً لمعرفة ما إذا كانت أبعاد الاستبانة وفقراتها مترابطة، وفي هذا البحث فإن تحليل العامل تم توظيفه لتحديد أبعاد الحواجز التي تعيق تقديم الخدمات الإلكترونية ضمن إطار البيئة الأردنية، وقد أكد استخدام تحليل العامل وجود خمسة معوقات هي (السياسية، الاقتصادية، العقبات المتعلقة بالمهارات التقنية، التكنولوجية، والتنظيمية).

التقنية الأخرى التي تم استخدامها لتحديد عدد العوامل الواجب المحافظة عليها للتحليل التالي هي تقنية تناوب العامل، والتي تقوم بتوضيح العوامل أو الأبعاد الخمسة لحواجز الخدمات الإلكترونية وتخفيض

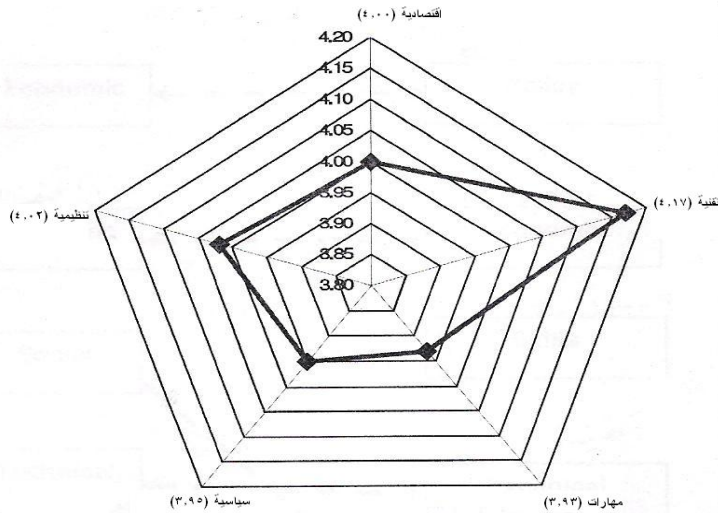
## المعوقات المدركة لخدمات الحكومة الإلكترونية من وجهة نظر موظفي القطاع العام الأردني: دراسة ميدانية

أي تشابك بينها، كما أنها تزيد قابلية تفسير هذه الحواجز، وباختصار فقد قام البحث بتأكيد وجود خمسة معوقات مختلفة أمام تقديم وتطوير الخدمات الإلكترونية وهي: المعوقات التكنولوجية التي تعنى أساساً بالبنية التحتية التقنية في مؤسسات القطاع العام، المعوقات التنظيمية المتعلقة بإعمال الحكومة واستراتيجيات الإدارة والثقافة التنظيمية، العقبات الاقتصادية التي تتعلق بنقص الموارد اللازمة لتبني وتنفيذ وتطوير الخدمات الإلكترونية، العقبات المتعلقة بالسياسة العامة حيث ينصب الاهتمام على التشريعات التي لا تنتهك الحريات المدنية، وأخيراً العقبات المتعلقة بالمهارات التقنية وخاصة نقص الكوادر المدربة والمستخدمين المهرة، ولتجنب تمثيل فقرة واحدة من كل حاجز، فقد تم احتساب متوسط جميع الفقرات التي تقيس كل متغير من متغيرات الدراسة واستخدامها لبيان ترتيب معوقات تقديم الخدمات الإلكترونية، وبما أن عدد الفقرات التي تقيس كل نوع من العقبات مختلف، فإن استخدام المتوسط عوضاً عن الفقرات المنفصلة يمكن أن يزيل أي محاباة تتعلق بالعدد المختلف للفقرات التي تمثل كل نوع من العقبات.

والجدول (1) يبين متوسطات عقبات تقديم الخدمات الإلكترونية. ويتضح من الجدول أن جميع العقبات متجمعة بشكل قريب معاً حول المتوسط (4) ولا يوجد هناك فروق كبيره بينها.

الجدول 1: متوسطات معوقات الخدمات الإلكترونية

| الترتيب | المتوسط | معوقات الخدمات الإلكترونية |
|---------|---------|----------------------------|
| 1       | 4.14    | معوقات تكنولوجية           |
| 2       | 4.02    | معوقات تنظيمية             |
| 3       | 4.00    | معوقات اقتصادية            |
| 4       | 3.95    | معوقات سياسية              |
| 5       | 3.93    | معوقات مهارات              |

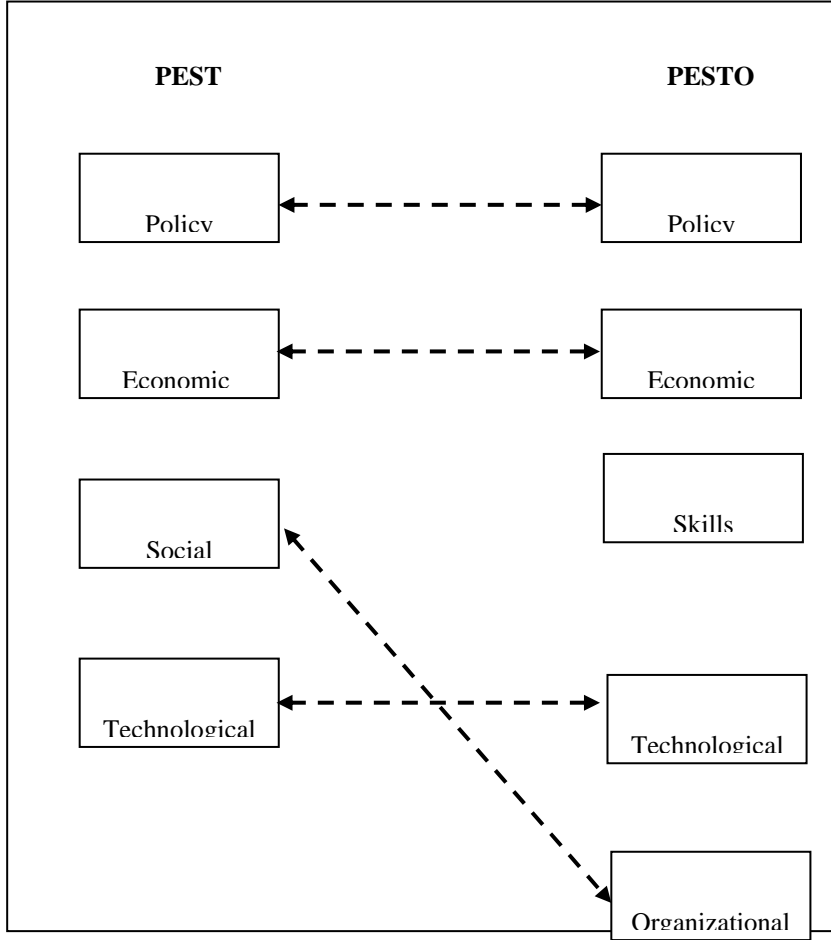


الشكل 1: توزيع عقبات تقديم الخدمات الإلكترونية وترتيبها حسب المتوسطات الحسابية

## العضايه

ويقدم الرسم البياني الراداري (الشكل 1) عرضاً تصويرياً لتوزيع متوسطات معوقات تقديم الخدمات الإلكترونية وترتيبها حسب المتوسطات الحسابية.

وكما تشير النتائج أعلاه فإن المعوقات التقنية المرتبطة بالتكنولوجيا تعتبر الأكثر أهمية بمتوسط حسابي (4,17)، بينما يتضح أن المعوقات التنظيمية والاقتصادية كانت قريبة (4.00-4.02) على التوالي، في حين إن المعوقات المتعلقة والسياسة العامة والمهارات جاءت أخيراً (3,93-3.95) على التوالي.



الشكل 2: النموذج المقترح (PESTO) مقارنة بالنموذج الحالي (PEST).

وتؤلف جميع هذه المعوقات ما يمكن تسميته بنموذج (PESTO) وهو نموذج معدل لنموذج (PEST) حيث يؤكد هذا النموذج أهمية المعوقات التنظيمية والمهارات التقنية وضرورة دراستها وتحليلها من أجل نجاح تجربة الخدمات الإلكترونية، ويبين الشكل (2) النموذج المقترح (PESTO) مقارنة بالنموذج الحالي (PEST).

المعوقات المدركة لخدمات الحكومة الإلكترونية من وجهة نظر موظفي القطاع العام الأردني: دراسة ميدانية

### مناقشة النتائج:

من أجل فهم أهمية الحواجز التي ربما تعيق تقديم الخدمات الإلكترونية وتطويرها ضمن نطاق البيئة الأردنية فمن الضروري أن إدراك إن هذه الحواجز تؤثر في الإستراتيجية الوطنية للحكومة الإلكترونية عموماً؛ وبالتالي على توفير الخدمات الإلكترونية خصوصاً، وفيما يلي مناقشة لهذه الحواجز ضمن إطار عمل (PESTO) حسب درجة أهميتها المدركة.

### أولاً: المعوقات التكنولوجية

الحواجز التكنولوجية وجد بأنها أكثر الحواجز أهمية أمام تطوير الخدمات الإلكترونية ضمن نطاق البيئة الأردنية، وعلى الرغم من أن الأردن قام بخطوات واعدة في بناء بنية تحتية تكنولوجية لدعم تبني الأردن للحكومة الإلكترونية وتوفير الخدمات الإلكترونية إلا أن هناك الكثير من المصاعب والتحديات التي لا بد من التعامل معها [3,17]، ومن هذه التحديات:-

- مشاكل عدم الانسجام من حيث المستوى التقني للمؤسسات الحكومية والذي يشكل عائقاً أمام تبادل البيانات بين الوزارات الأردنية المختلفة والمؤسسات الحكومية الملحقة بها، ففي الوقت الذي تقوم فيه الوزارات باستخدام آخر ما توصل إليه العلم من التكنولوجيات فإن المؤسسات المرتبطة بتلك الوزارات تستخدم أجهزة الحاسوب الشخصي البسيطة [10].
- ضعف وسائل الاتصالات الإلكترونية أو عدم استخدام المتاح منها بشكل فعال [5].
- نقص المتخصصين من ذوي الكفاءة العالية في مجال تكنولوجيا المعلومات والاتصالات في القطاع العام مما يعني أن تصميم البنية التحتية سيكون من مسؤولية الموردين والكفاءات الخارجية الذين ربما لا يدركون بشكل كافي طبيعة مؤسسات القطاع العام [10]، وأشار الجاغوب وسترب [3] إلى أنه على الرغم من أن الأردن يستثمر بقوة في التعليم المرتبط بتكنولوجيا المعلومات والاتصالات والتدريب إلا أن هذا لا يحدث الكثير من التغيير لأنه حالما يصبح الأشخاص مدربين ويكتسبوا الخبرة، فإنه يتم اجتذابهم إلى خارج الأردن أو إلى مؤسسات القطاع الخاص داخل الأردن حيث تتوافر الرواتب المجزية. ويبدو من خلال ما سبق أن من الجهود الحكومية المبذولة لرفع كفاءات ومهارات الموارد البشرية بما يهيئ لهذه الموارد تقبل وتأقلم التغييرات الجديدة وبما يضمن الحفاظ على مستوى عال من الإنتاجية وتحمل المسؤولية والاستمرارية في تحسين الأداء لم تحقق المطلوب، ويجدر الذكر أن مبادرات التدريب وبناء القدرات التي يشرف عليها برنامج الحومة الإلكترونية في وزارة الاتصالات وتكنولوجيا المعلومات قد شملت تدريب أكثر من 10000 موظف حكومي منذ 2003 [45]، وقد يعود ذلك لطبيعة البرامج التدريبية ومدى ملائمتها لطبيعة الخدمات الحكومية الإلكترونية.

### ثانياً: المعوقات التنظيمية:

وجد بأن المعوقات التنظيمية هي ثاني أكثر الحواجز أهمية ضمن نطاق البيئة الأردنية، وكما هو الحال في غالبية الدول النامية فإن المؤسسات العامة في بيئة البحث تتعدد مستويات صنع القرار فيها، كما يكثر استخدام اللجان التوجيهية التي ربما تعقد عملية صنع القرار [31,42]، ويمكن اعتبار نقص التنسيق

## العضايه

والدمج بين المؤسسات المختلفة ووجود رؤى واتجاهات مختلفة تهديداً للتنفيذ الفعلي الفاعل للخدمات الإلكترونية، كما أن ضعف إطار العمل المؤسسي الملائم والقيادة الميدانية لقيادة الخدمات الإلكترونية تخفض قدرة الحكومة على التنسيق الفاعل وتنفيذ المبادرات الإلكترونية [10]، وحاجز هام آخر يتصل بالجانب التنظيمي وهو مقاومة الموظفين للتغيير قبل وخلال استخدام أنظمة الحكومة الإلكترونية والذي ربما يعتبر سبب رئيساً لفشل المبادرة الإلكترونية، والأشكال الأساسية للمقاومة السلبية مثل اللامبالاة وقلة الاهتمام والتذمر يمكن أن تتطور إلى المزيد من أشكال التصادم لتغيير إرث الحكومات [23,11,28,17]، والأردن ليس قاعدة استثنائية، فعندما يأتي الأمر للأشكال المختلفة من المقاومة البشرية والمؤسسية فإنه يكون مثل غالبية بلدان العالم المترامي الأطراف حيث أن الخوف من فقدان الوظيفة وإعادة الهيكلة يمكن أن تؤثر على اتجاهات الموظفين تجاه تقديم الخدمات الإلكترونية، وهذا بدوره سيؤدي لإضعاف الجهود لجعل الخدمات الإلكترونية جزءاً من الثقافة المؤسسية، ووفقاً لمؤسسة التدريب الأوروبية [13]، فإن الأردنيين يفضلون العمل في القطاع العام بسبب المزايا والفوائد التي يوفرها، مثل الأمن الوظيفي، وساعات العمل الأقل والوضع الاجتماعي المفضل، لذلك فمن المتوقع أن موظفي القطاع العام سيقاومون أي تغيير، وخصوصاً تحويل الخدمات التقليدية إلى خدمات إلكترونية في مؤسساتهم، لأنهم يخافون أن مثل هذا التغيير سيضعف أدوار وظائفهم أو ربما يفقدتهم تلك الوظائف، وبالتالي فإن المعوقات التنظيمية تصبح عقبة أمام تطبيق وتطوير الخدمات الإلكترونية.

### ثالثاً: المعوقات الاقتصادية:

لقد أشارت الدراسة الحالية إن الحواجز الاقتصادية بالغة الأهمية في البيئة الأردنية، وهذا مبرر في دولة لها دخل متوسط ومصادر طبيعية شحيحة [3]، وبشكل عام فإن الحواجز الاقتصادية أو المالية لتطوير الخدمة الإلكترونية لقيت الكثير من الاهتمام في الأدبيات والدراسات السابقة، وقد أشارت معظم هذه الدراسات إلى أن التحول من الخدمات التقليدية إلى الخدمات الإلكترونية من خلال تبني الحكومة الإلكترونية يتطلب ميزانية ضخمة لتركيبة وتشغيل وصيانة الأنظمة وتقديم الاستشارات وتدريب الكوادر البشرية [21,16,11]، وتزداد أهمية الحواجز الاقتصادية عند معرفة أن الأردن دولة ذات مصادر محدودة جداً حيث أن 95% من ميزانية الحكومة تأتي من القروض والمنح [10]، كما بلغ حجم قطاع الخدمات حوالي 49% من حجم الناتج المحلي الإجمالي عام 2003 مع إسهام قطاع تكنولوجيا المعلومات بحوالي 2,9% من قطاع الخدمات [19]، وتبعاً للتقرير الذي نشرته جريدة الجوردان تايمز فقد ازدادت عوائد قطاع تكنولوجيا المعلومات الاتصالات الأردنية لتبلغ 12% من إجمالي الناتج المحلي [36].

وعلى الرغم من ذلك، فإن الاعتماد الكبير على التحويلات الخارجية يكتنفه مجازفة كبرى حيث أنه إذا انخفضت التحويلات الخارجية لسبب أو لآخر فإن الحكومة لن تكون قادرة على تحمل النفقات الباهظة لتوفير الخدمات الإلكترونية، وهذه الحقيقة تتضح من خلال ملاحظات بعض المشاركين في الدراسة الذين أكدوا أنه على الرغم من أن هناك مصادر مالية شحيحة في الأردن فقد خصصت الحكومة ميزانية ضخمة لتطوير الخدمات الإلكترونية اعتماداً على المساعدات والمنح الخارجية، وإذا لم يتم إدارة عملية تطوير الخدمات الإلكترونية مالياً بشكل جيد فإننا نتعرض لخسارة ثقة المانحين.

المعوقات المدركة لخدمات الحكومة الإلكترونية من وجهة نظر موظفي القطاع العام الأردني: دراسة ميدانية

#### رابعاً: المعوقات المتعلقة بالسياسة العامة:

كانت الحواجز السياسية واضحة ضمن إطار البيئة الأردنية، إن نقص الاستراتيجيات الواضحة التي تؤدي إلى عملية التحول من التنظيمات التقليدية إلى بيئة إلكترونية هي عائق هام [33]، وبالرغم من أن هذا التحول يتلقى الدعم من قبل القيادة السياسية للملك عبد الله الثاني إلا أن الحكومة لم تقطع مسافة طويلة في ترجمة هذا الدعم إلى نتائج ملموسة، فعلى سبيل المثال فقد قامت الحكومة بتفعيل قانون التحول الإلكتروني المؤقت رقم (85) لعام 2001 عام 2001 [2]، وقد تم تطبيق هذا القانون على جميع التحويلات الإلكترونية والسجلات والتواقيع، حيث تم إقرار تبني واستخدام الوسائل الإلكترونية، ومع ذلك فإن هذا لا يعني استبعاد تطبيق القانون التقليدي، وهذا يتضح من خلال وجود الكثير من الخدمات الإلكترونية مستبعدة من هذا القانون مما يعني ضرورة الحصول على هذه الخدمات بالشكل التقليدي، ومن هذه الخدمات الإشعارات المتعلقة بفصل الماء والكهرباء والتأمين والرسوم وتعديلات الوصية وإجراءات استئناف أحكام المحاكم [4]، وهذه بالتالي يعيق تطوير الخدمات الإلكترونية التي تركز على المواطن لذلك فلا زالت هناك حاجة للمزيد من الإجراءات الداعمة والتشريعات والتعليمات لتسهيل التحول والمساعدة على توجيه تنفيذ الخدمات الإلكترونية في الأردن [5].

كما تبدو الحكومة قلقة بخصوص الوصول غير المقيد إلى المعلومات العامة والخدمات الإلكترونية باعتبار ذلك ربما يؤثر في الاستقرار الاجتماعي [5,2]، كما يبدو جانب الخصوصية بالنسبة للمستخدمين من الخدمات الحكومية الإلكترونية على جانب كبير من الأهمية في ظل النقص في أنظمه الخصوصية مما يضعف ثقة المستخدمين من الخدمات الإلكترونية.

#### خامساً: المعوقات المتعلقة بالمهارة التقنية:

على الرغم من أن الكثير من المبادرات سعت لجعل الانترنت جزءاً من الحياة الأردنية الاجتماعية والثقافية على المستوى الوطني فقد وجد أن الحواجز المتعلقة بالمهارات التقنية لازالت قائمة وعلى قدر كبير من الأهمية، ومن هذه المبادرات شعار جهاز حاسوب في كل بيت الذي أطلق عام 2004 والذي يهدف لرفع معدلات استخدام الانترنت وأجهزة الحاسوب خصوصاً بالنسبة للمناطق "الأقل حظاً"، ومن المبادرات الأخرى مبادرة محطة المعرفة التي أطلقت عام 2000 بغاية تمكين شرائح المجتمع الأردني دونما اعتبار لمواقعها أو حالتها الاقتصادية من اكتساب المهارات الضرورية المتعلقة باستخدام التكنولوجيا، كما تم طرح برنامج معرفة الذي يقدم الفرصة لموظفي القطاع العام ليتدربوا وفق معايير معتمدة على نطاق عالمي مثل دورات الرخصة الدولية لقيادة الحاسوب ودورة تدريب كامبردج [23]، وعلى الرغم من أن تأثيرات مثل هذه المبادرات كانت محسوسة إلى حد معين، فالحقيقة الباقية أن التقسيم الرقمي الضخم لا زال موجوداً ضمن نطاق البيئة الأردنية، وهذا التقسيم الرقمي يمكن أن يوسع حواجز المهارة ما بين المستخدمين المختلفين، وربما يعود ذلك إلى عدم وجود سياسة واضحة لتخفيض تكاليف الوصول إلى الانترنت [10]، وهذه الحقيقة تصبح قابلة للفهم إذا القينا نظرة على الدخل السنوي في الأردن، فتبعاً إلى آخر مسح تم إجراءه من قبل دائرة الإحصاءات العامة الأردنية بين الأعوام (2002-2006)، فإن الدخل السنوي للشخص بالمعدل هو 1,082 دينار أردني [35]، وهذا يعيق استخدام الإنترنت وبالتالي الخدمات الإلكترونية.

## العضايله

وسبب آخر للتقسيم الرقمي هو نقص المهارات الضرورية ما بين مجموعات معينة من الناس مثل المسنين والأشخاص والأقل تعليماً [7]، وهذه العوامل يمكن أن تنطبق على البيئة الأردنية جاعلة التقسيم الرقمي أوسع انتشاراً ويمكن أن يكون عقبة خطيرة أمام الاستفادة من الخدمات الإلكترونية.

### الخلاصة والتوصيات:

وباختصار، فإن البحث قام بمراجعة الأدبيات والدراسات السابقة حول واقع معوقات الخدمات الحكومية الإلكترونية، كما حددت الدراسة الحالية إطار عمل يضم خمسة معوقات رئيسية، هي: السياسية، والاقتصادية، والمهارات والتقنية، والتنظيمية (PESTO)، وعلى النقيض لغالبية العمل في حواجز الخدمات الإلكترونية، فإن هذا البحث ربط بشكل عملي هذه المعوقات مع مدركات المزدودين لإضفاء المصداقية على إطار العمل المقترح للبيئة الأردنية، ويقدم تفسيراً ثرياً ومناقشة للنتائج.

وقد خلصت الدراسة إلى تقديم التوصيات التالية:

1. التركيز على توفير البنية التحتية التقنية الملائمة لتطوير وتفعيل الخدمات الحكومية الإلكترونية ضمن الإمكانيات المتاحة وترتيب أولويات المشاريع الحكومية حيث اتفقت هذه الدراسة مع نتائج بعض الدراسات السابقة على عدم كفاية البنية التحتية الحالية وأكدت الحاجة إلى تعزيزها مع ضرورة الاستغلال الأمثل للبنية الحالية.
2. ضرورة استكمال الإطار التشريعي للخدمة الإلكترونية وتوسيع دائرة الخدمات المقدمة إلكترونياً لتشمل بعض الخدمات الحيوية التي تدفع المستفيدين نحو بناء المهارات كضرورة للحصول على الخدمات الحكومية.
3. الاستمرار في طرح المبادرات الهادفة إلى تطوير مستوى المهارات التقنية حيث من الملاحظ البطء في وتيرة هذه المبادرات في السنوات القليلة الأخيرة.
4. ضرورة الاهتمام بعنصر التهيئة التنظيمية من حيث نشر المعلومات وتعزيز الثقافة التنظيمية الداعمة للتغيير نحو الأفضل وتوفير القيادات الإدارية المنفتحة بالإضافة إلى مشاركة العاملين في رسم وتنفيذ استراتيجيات برنامج الحكومة الإلكترونية.
5. إجراء المزيد من الدراسات حول الجوانب المختلفة للحكومة الإلكترونية مثل إدراك المستفيدين من الخدمات الحكومية لمعوقات الخدمات الإلكترونية بالإضافة إلى الجوانب التشريعية والإجرائية والتنظيمية المرتبطة بتقديم الخدمات الإلكترونية.
6. كما يجب أن تقوم بعض الدراسات مستقبلاً بدراسة مدى ملائمة التهيئة التقنية من حيث كفاءة البرامج التدريبية وبرامج تطوير القدرات ومدى كفاءة البرمجيات والمعدات الحاسوبية وكفائتها واليات تفعيله وتطويرها لترقى بالمستوى التقني للموارد البشرية والمادية في المؤسسات الحكومية.
7. إن الدراسة الحالية قد ركزت على وجهات نظر موظفي القطاع العام لذلك تبدو الحاجة ماسة لتناول وجهات نظر مختلفة ممثلة لشرائح المجتمع الأردني المتعددة.

## Perceived Barriers to E-Government Services from the Perceptive of Jordanian Public Sector's Employees: An Empirical Study

Raid Al- Adaileh

### Abstract

This study aims to determine the barriers that hamper the development of e-government services within the context of Jordanian government. The study attempts to develop a model to identify those barriers. To achieve this aim, a questionnaire was distributed to (484) participants who participate in the provision of e-government services. The participants were selected using a convenient sampling method. Data were analyzed using factor analysis to determine the appropriateness of the questionnaire which was adopted from The Oxford Institute of the Internet. Descriptive statistics were used to identify the barriers facing the introduction of e-government services from the of participants' perspective in addition to the order of these barriers. Analysis showed that there are five major barriers facing the introduction of e-government services within the context of Jordanian environment. These barriers, according to their importance, include: the technological factors, organizational factors, economic factors, factors related to policy, and the factors associated with the technical skills. This confirmed the proposed (PESTO) model. Finally, comprehensive discussion and interpretation of the findings were provided in addition to some recommendations to decision makers within the context of the Jordanian government.

**Keywords:** Electronic environment, electronic services, barriers, Jordan, developing countries.

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## خصائص التكاثر لدى أسماك *Capoeta trutta* (Heckel, 1843) في بحيرة تشرين (نهر الفرات)

زهير أحمد المجيد\* ومها جاد شلقة\*

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### ملخص

تمت دراسة بيولوجية التكاثر عند أسماك *Capoeta trutta* في بحيرة تشرين(سوريا) وذلك من خلال تحديد: التركيب الجنسي والعمرى، عمر البلوغ الجنسي، التفريخ، الخصوبة وعلاقتها مع الطول والوزن ووزن المبيض، فترة التكاثر. وتبين أن نسبة الذكور والإناث في 265 عينة كانت (52.04%)، (47.96%) على التوالي وهي نسبة قريبة من النسبة (1:1). توزعت العينات على سبع فئات عمرية(سنة)، وكان عمر البلوغ الجنسي الأول للذكور في السنة الثانية، حيث بلغت نسبة الذكور (76.92%)، أما الإناث فكان عمر بلوغها الجنسي الأول في السنة الثالثة حيث بلغت نسبة الإناث (68.75%). أما فترة التفريخ فقد امتدت بداية شهر حزيران وحتى شهر آب وذلك إستناداً الى قيم (*GSI*) والمراقبة المباشرة لتطور المناسل والبيوض. أما القطر الوسطي للبيوض الناضجة فكانت ( $1.38 \pm 0.15$  mm)، وتراوحت الخصوبة بين (9850-29884) بيضة. أما علاقة إرتباط الخصوبة (*F*) مع كل من طول الجسم (*FL*)، وزن الجسم (*W*) ووزن المبيض (*GW*) كانت على التوالي: ( $r^2 = 0.67$ )، ( $r^2 = 0.72$ )، ( $r^2 = 0.65$ ). الكلمات المفتاحية: عمر البلوغ الجنسي، التفريخ، الخصوبة، *Capoeta trutta*، بحيرة تشرين.

### مقدمة

تقع بحيرة تشرين على نهر الفرات، يبلغ طولها 46 كم وعرضها 6.5 كم ويقدر إستيعابها المائي بأربعين مليون متر مكعب. تشكل هذه البحيرة مصدراً لإنتاج الطاقة الكهربائية وري الأراضي، كما أنها تشكل مصدراً لإنتاج الأسماك.

تعد أسماك *Capoeta trutta* أحد أنواع الفصيلة الشبوطية *Cyprinidae* الشائعة والواسعة الانتشار في التجمعات المائية العذبة، ومنها بحيرة تشرين(نهرالفرات). إن الدراسات المتعلقة بالفاونا السمكية في المياه العذبة في سوريا، قديمة نسبياً ففي أربعينيات القرن التاسع عشر قام الباحث هيكل (Heckel) بتصنيف أسماك المياه العذبة في سوريا فوصف (36 نوعاً) [10]، وأجريت في القرن العشرين دراسات كثيرة تصنيفية على أسماك المياه العذبة في سورية، أهمها دراسة الباحث بيكمان حيث حدد إنتشار ووجود (86 نوعاً) [5]، وتم لاحقاً معالجة بعض الجوانب البيولوجية لبعض الأسماك والأحياء

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\* قسم علم الحيوان، كلية العلوم، جامعة تشرين، اللاذقية، سوريا.

## المجيد وشلفة

المائية في بحيرة الاسد من قبل الهيئة الألمانية للتعاون التقني [1]، كما قدم الباحث كود (Coad) تقريراً، أكد فيه على وجود 66 نوعاً من الأسماك المحلية والمدخلة في نهري دجلة والفرات [6،7،8] وتشير الوثائق التي قدمها المشروع السوري - الألماني [11]، والخاصة بتطوير الثروة السمكية في المياه الداخلية السورية، الى وجود (28) نوعاً من الأسماك المحلية في مياه نهر الفرات، إضافة للأنواع المدخلة. وأجريت في عام 2003 دراسة حول "التركيب النوعي والكمي والتوزيع الجغرافي الحيوي للأسماك في حوض نهر الخابور" [2]، وأجرى الباحث رامز الحزا دراسة حول بعض الخصائص البيولوجية لأسماك *Barbus luteus* في نهر الفرات [4]. وتعتبر الدراسة الحالية عن بيولوجيا التكاثر عند أسماك *Capoeta trutta* الدراسة الأولى في المياه السورية ومن هنا تأتي أهميتها، لأنها تلقي الضوء على أهم الجوانب البيولوجية التي يتمتع بها هذا النوع من الأسماك.

### أهداف البحث:

- 1- تحديد التركيب الجنسي والعمرى لأسماك *Capoeta trutta*.
- 2- دراسة التكاثر من خلال تحديد كل من: (عمر البلوغ الجنسي، فترة التكاثر، الخصوبة وإرتباطها مع كل من الطول، الوزن ووزن المناسل).

### الاختصارات

|      |   |   |
|------|---|---|
| GSI  | Gonad Somatic Index                                       | معامل النضج                                   |
| GW   | Gonad Weight  | وزن المناسل                                   |
| BW   | Body Weight   | وزن الجسم بدون أحشاء                          |
| F    | Fecundity   | الخصوبة                                       |
| L    | Length  | الطول   |
| W    | Weight  | الوزن   |
| n    | Number of Samples   | عدد العينات                                   |
| sd   | Standard Deviation  | الإنحراف المعياري                             |
| GTZ  | Germany Agency for Technical Cooperation                  | الهيئة الألمانية للتعاون التقني               |
| IFAP | Syian-German Inland Fisheries and Aquaculture Development | المشروع السوري الألماني لتطور الزراعة السمكية |

### المواد وطرائق البحث:

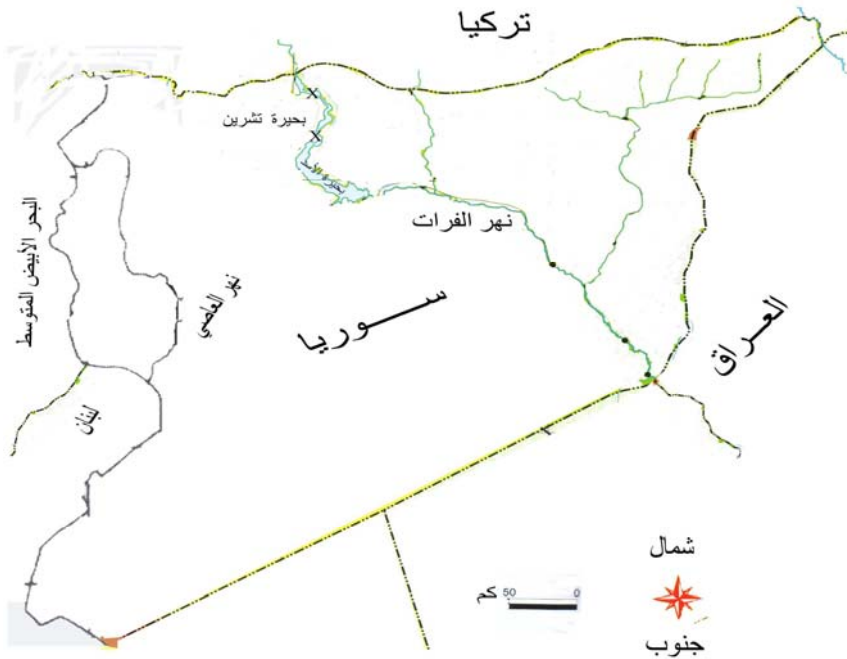
تمت الدراسة على 265 عينة لأسماك *Capoeta trutta* (138 ذكور، 127 إناث) في بحيرة تشرين (الشكل 1) وقد توزعت على سبع فئات عمرية. جمعت العينات شهرياً خلال الفترة الممتدة ما بين تشرين الثاني 2007 وكانون الأول 2008. وقد تم استخدام شبك الخياشيم ذات فتحات مختلفة الأقطار (15mm×15mm, 18×18mm, 24×24mm, 30×30mm). أخذت أطوال العينات وأوزانها، وكانت القيم قريبة من (1مم) و(0.1غ) على التوالي. نزعت 10 حراشف من المنطقة الوسطى لجانب الجسم فوق الخط الجانبي. تم تشريح العينات وأخذت منها المناسل حيث حفظت، بعد وزنها، في محلول الفورمالين 4%.

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وكان وزنها قريباً من (0.01غ). ومن أجل تحديد العمر وضعت الحراشف في محلول ماءات الأمونيوم تركيز 4% لمدة 24 ساعة بعد ذلك تمت قراءتها تحت مجهر عادي [17]. وقد تم تحديد عمر البلوغ الجنسي من قيم معامل النضج (*GSI*) والمراقبة العينانية للعينات الكبيرة أو بمساعدة المجهر بالنسبة للعينات الصغيرة في الفترة الممتدة من النصف الثاني لشهرايار وحتى شهر تموز. وقد تم حساب تغيرات معامل النضج من المعادلة:

$$GSI = \frac{GW (g)}{BW (g)} \times 100$$

حددت الخصوبة بواسطة الطريقة الوزنية باستخدام المبايض وهي في الطور *V* من النضج، حيث تم أخذ ثلاث عينات من المناسل وحسب عدد البيوض في كل جزء، ثم أخذ المتوسط لها ونسب إلى الوزن الكلي للمبايض [14]. أما لحساب القطر الوسطي للبيوض، فقد تم إختيار 20 بيضة عشوائياً من كل مبيض وقيست أقطارها تحت مجهر مزود بعدسة عينية ذات مسطرة ميكرومترية [14]. من جهة أخرى فإن علاقات إرتباط الخصوبة (*F*) مع كل من الطول الكلي (*FL*)، وزن الجسم (*W*) ووزن الغدد التناسلية (*GW*) هي من الشكل ( $F = aFL^b$ )، ( $F = aW^b$ )، ( $F = aGW^b$ ) وهي معادلات تؤول إلى الشكل الخطي إعتماًداً على القيم اللوغاريتمية المحولة، حسبت ثوابت المعادلات السابقة بواسطة المربعات الصغرى [16].



شكل (1): مخطط يظهر منطقة البحث التي تم جمع العينات منها (بحيرة تشرين)

النتائج:

1- التركيب الجنسي والعمرى:

توزعت العينات 265 على سبع فئات عمرية (جدول 1).

الجدول (1): التركيب الجنسي والعمرى لأسماك *Capoeta trutta* في بحيرة تشرين.

| ♀ + ♂ |     | ♀     |     | ♂     |     | الفئات العمرية (سنة) |
|-------|-----|-------|-----|-------|-----|----------------------|
| %     | n   | %     | n   | %     | n   |                      |
| 6.79  | 18  | 2.64  | 7   | 4.15  | 11  | I                    |
| 15.47 | 41  | 6.79  | 18  | 8.67  | 23  | II                   |
| 19.24 | 51  | 5.66  | 15  | 13.58 | 36  | III                  |
| 20.37 | 54  | 9.81  | 26  | 10.56 | 28  | IV                   |
| 17.73 | 47  | 10.56 | 28  | 7.92  | 21  | V                    |
| 15.47 | 41  | 9.05  | 24  | 6.41  | 17  | VI                   |
| 1.88  | 5   | 3.39  | 9   | 0.75  | 2   | VII                  |
| 100   | 265 | 47.96 | 127 | 52.04 | 138 | المجموع              |

يظهر من الجدول أن الفئات العمرية السبعة موزعة على النحو التالي (6.79%) للفئة الأولى، (15.47%) للفئة الثانية (19.24%) للفئة الثالثة، (20.37%) للفئة الرابعة، (17.73%) للفئة الخامسة، (17.73%) للفئة السادسة و(1.88%) للفئة السابعة حيث كانت الفئة العمرية الثالثة والرابعة هما الغالبتان. توزع الجنس في الفئات كافة لا يظهر إنحرافاً مميّزاً عن النسبة (1:1) حيث كانت نسبة الإناث (47.96%)، أما الذكور (52.04%) أي أن كل 1 ذكر يقابله 0.92 أنثى.

2- عمر البلوغ الجنسي:

تبين العينات (154) التي تم جمعها في الفترة الممتدة من شهر أيار وحتى شهر تموز، بأن (68.75%) من الإناث قد نضجت في السنة الثالثة من العمر ولم يلاحظ أي عينة غير ناضجة جنسياً في الفئة العمرية IV، بينما كانت نسبة الذكور الناضجة في السنة الثانية (76.92%) ولم يلاحظ أي عينة غير ناضجة جنسياً في الفئة العمرية III، (جدول 2)

الجدول (2): عمر البلوغ الجنسي لأسماك *Capoeta trutta* في بحيرة تشرين (نهر الفرات).

| ♂     |       |       |   | ♀  |       |     |    | الفئات العمرية |
|-------|-------|-------|---|----|-------|-----|----|----------------|
| %     | ناضجة | %     | n | %  | ناضجة | %   | n  |                |
| 0     | 0     | 100   | 8 | 0  | 0     | 100 | 6  | I              |
| 76.92 | 10    | 23.07 | 3 | 0  | 0     | 100 | 11 | II             |
| 100   | 17    | 0     | 0 | 17 | 68.75 | 10  | 5  | III            |
| 100   | 15    | 0     | 0 | 15 | 100   | 19  | 0  | IV             |
| 100   | 10    | 0     | 0 | 10 | 100   | 17  | 0  | V              |
| 100   | 6     | 0     | 0 | 6  | 100   | 9   | 0  | VI             |
| 100   | 2     | 0     | 0 | 2  | 100   | 5   | 0  | VII            |

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### 3- التفريخ:

حددت فترة التكاثر لأسماك *Capoeta trutta* في بحيرة تشرين اعتماداً على قيم معامل النضج (GSI) والمراقبة المباشرة لتطور المناسل، وتحليل التغير والتطور الفصلي في قطر البيوض، حيث بدأ التكاثر من بداية شهر حزيران وحتى شهر آب كما يتضح من (الجدول 3) و(الجدول 4).

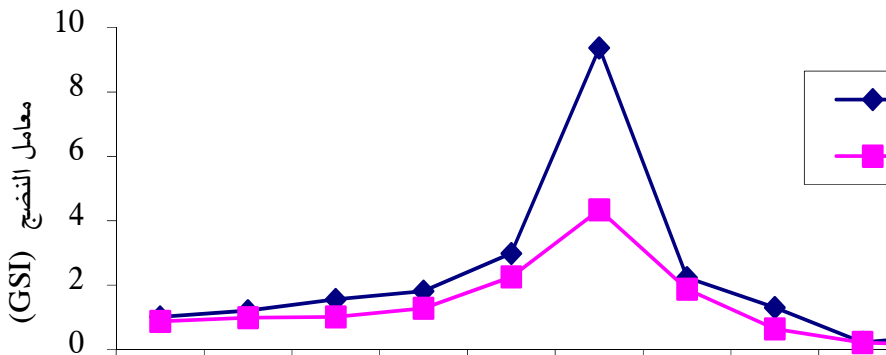
**الجدول (3):** تغيرات معامل النضج لذكور وإناث أسماك *Capoeta trutta* في بحيرة تشرين

| الأشهر | ك2   | ش    | أز   | ن    | أي   | ح    | ت    | أب   | إ    | ت1   | ت2   | ك1   |
|--------|------|------|------|------|------|------|------|------|------|------|------|------|
| GSI(♀) | 1.01 | 1.2  | 1.55 | 1.81 | 2.98 | 9.37 | 2.23 | 1.3  | 0.22 | 0.45 | 0.82 | 0.99 |
| GSI(♂) | 0.87 | 0.98 | 1.01 | 1.27 | 2.25 | 4.33 | 1.87 | 0.63 | 0.21 | 0.13 | 0.43 | 0.76 |

**الجدول (4):** تغيرات أقطار البيوض عند أسماك *Capoeta trutta* في بحيرة تشرين

| الأشهر | متوسط قطر البيوض (مم) $sd \pm$ | الخطأ القياسي | n  |
|--------|--------------------------------|---------------|----|
| شباط   | $0.69 \pm 0.059$               | 0.029         | 4  |
| أذار   | $0.806 \pm 0.14$               | 0.049         | 7  |
| نيسان  | $0.937 \pm 0.111$              | 0.033         | 11 |
| أيار   | $1.101 \pm 0.154$              | 0.054         | 8  |
| حزيران | $1.382 \pm 0.151$              | 0.057         | 7  |

لوحظ أن القيم الأعلى كانت في عينات شهر حزيران، وكان هناك إنخفاض في القيم الوسطية في عينات بقية الأشهر، لأن معظم الأفراد كانت قد وضعت البيوض آنذاك، حيث لوحظ أن المناسل بعد التفريخ إنتقلت الى الطور السادس والثاني الذي لم يدم طويلاً، ثم إنتقلت المناسل الى الطور الثالث لتطور المناسل الذي امتد من شهر آب وحتى منتصف شهر نيسان من العام الذي يلي، أما الطور الرابع فقد إستمر حتى نهاية شهر أيار الذي انتهى بالطور الخامس في شهر حزيران (الشكل 2).



شكل (2): تغيرات معامل النضج لذكور وإناث أسماك *Capoeta trutta* في بحيرة تشرين

#### 4- الخصوبة:

قدرت الخصوبة لاحدى وأربعين أنثى بعدد البيوض وكانت مبايضها في الطور V من النضج، وقد تراوحت الخصوبة ما بين (9850-29884) بيضة، وكان القطر الوسطي للبيوض الناضجة (0.151 mm ± (جدول 5).

الجدول (5): الخصوبة والطول والوزن لأسماك *Capoeta trutta* في بحيرة تشرين

| n  | الخصوبة                           |              | الوزن                     |            | الطول                     |             | الفئات العمرية |
|----|-----------------------------------|--------------|---------------------------|------------|---------------------------|-------------|----------------|
|    | Mean± sd                          | Mim-Max(egg) | Mean±sd                   | Mim-Max(g) | Mean± sd                  | Mim-Max(cm) |                |
| 5  | 10123±246.81<br>(9850-11250)      |              | 193±17.49<br>(169-213)    |            | 21.03±1.1<br>(19.9-22.8)  |             | III            |
| 11 | 12511.22±1657.34<br>(10420-15010) |              | 271.66±37.15<br>(218-318) |            | 24.76±2.07<br>(21.6-27.5) |             | IV             |
| 15 | 16906.71±1931.65<br>(13708-20230) |              | 342.14±27.43<br>(288-374) |            | 29.1±2.03<br>(25.8-32.4)  |             | V              |
| 8  | 23878.09±2954.1<br>(19667-28050)  |              | 412±55.17<br>(296-465)    |            | 34.4±2.1<br>(31.5-37.9)   |             | VI             |
| 2  | 27631.5±3185<br>(25379-29884)     |              | 495±13.43<br>(486-505)    |            | 37.53±1.2<br>(36.5-38.5)  |             | VII            |

وكانت علاقة الارتباط بين الخصوبة ( $F$ ) وكل من طول السمكة ( $FL$ )، ووزنها ( $W$ ) ووزن المبايض ( $GW$ ) علاقة إيجابية، كما يتضح من المعادلات التالية (والأشكال 3، 4، 5 التالية):

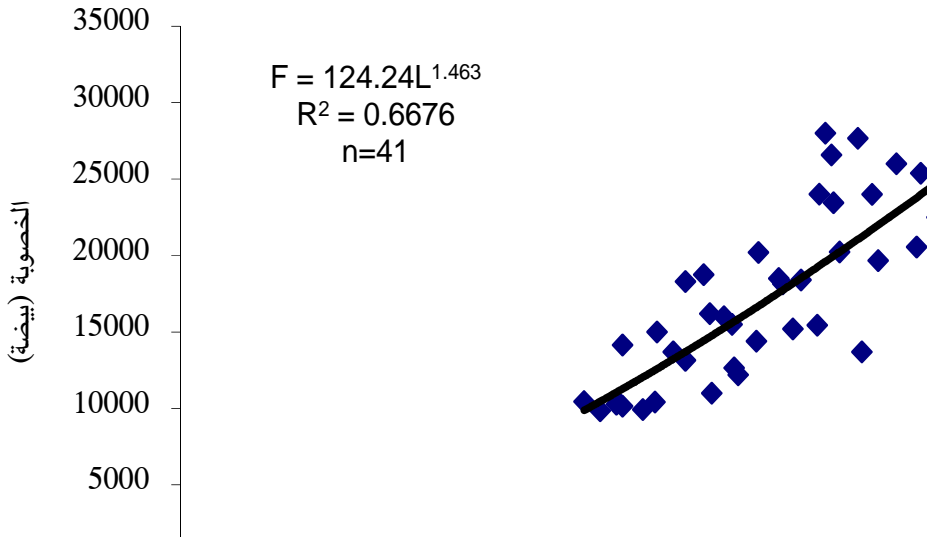
$$\text{Log}(F) = 2.0942 + 1.4623\text{Log}(FL), \quad (r^2 = 0.67)$$

$$\text{Log}(F) = 1.8023 + 0.9616\text{Log}(W), \quad (r^2 = 0.72)$$

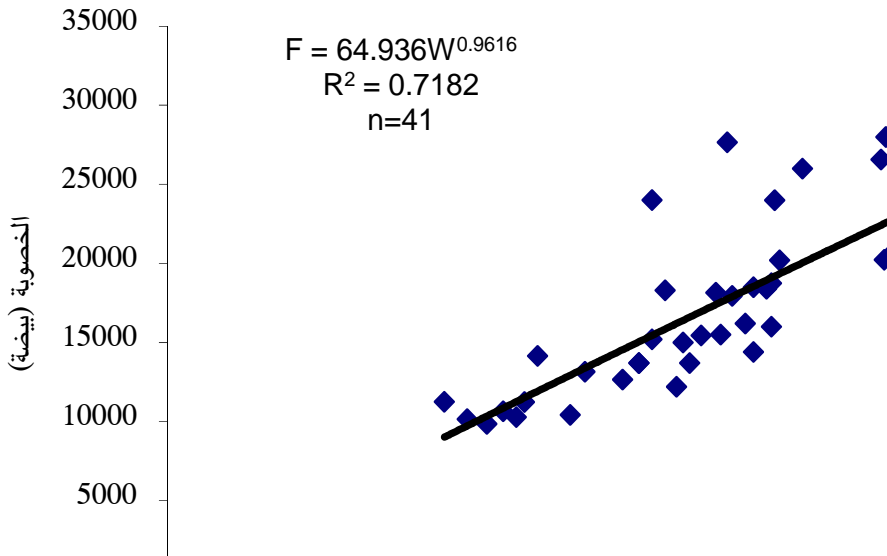
$$\text{Log}(F) = 3.2576 + 0.4972\text{Log}(GW), \quad (r^2 = 0.65)$$

ويلاحظ إن العلاقة بين الخصوبة مع كل من الطول، ووزن الجسم ووزن المبايض هي علاقة إرتباط إيجابية، لكن الخصوبة أكثر إرتباطاً مع وزن الجسم، لذلك فإن هناك إتجاه واضح في زيادة أعداد البيوض بزيادة وزن السمكة بشكل أكبر منه بزيادة طول الجسم ووزن المبايض.

خصائص التكاثر لدى أسماك *Capoeta trutta* (Heckel, 1843) في بحيرة تشرين (نهر الفرات)

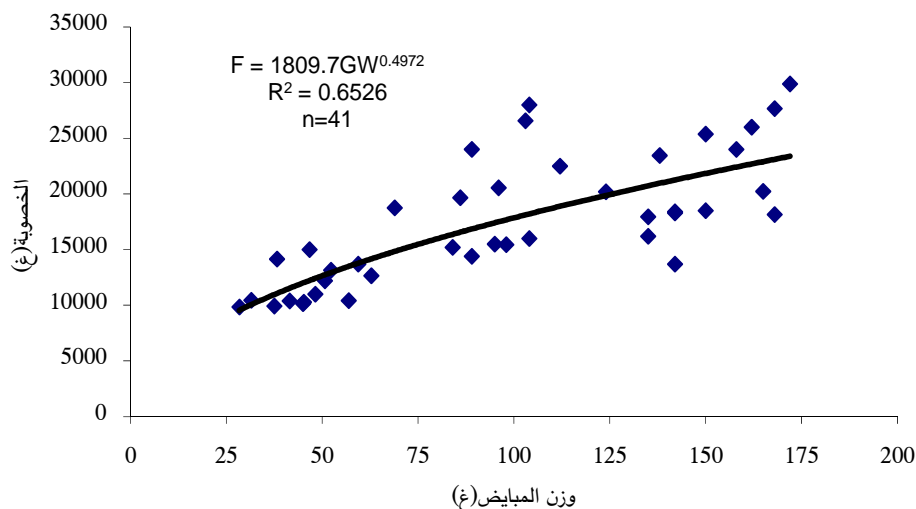


الشكل (3): علاقة الخصوبة مع الطول لدى أسماك *Capoeta trutta* في بحيرة تشرين



الشكل (4): علاقة الخصوبة مع الوزن لدى أسماك *Capoeta trutta* في بحيرة تشرين

### المجيد وشلفة



الشكل (5): علاقة الخصوبة مع وزن المناسل لدى أسماك *Capoeta trutta* في بحيرة تشرين

### المناقشة:

تبيّن أن أسماك *Capoeta trutta* في بحيرة تشرين (نهر الفرات) والتي تراوحت أعمارها بين الفئات العمرية من واحد إلى سبعة (I-VII)، قد توزعت على الشكل التالي: 6.79% للفئة الأولى، 15.47% للفئة الثانية، 19.24% للفئة الثالثة، 20.37% للفئة الرابعة، 17.73% للفئة الخامسة، 17.73% للفئة السادسة و1.88% للفئة السابعة حيث كانت نسبيتي الفئة العمرية الثالثة والرابعة هما الأعلى، أما توزع الجنس في الفئات كافة فلا يظهر إنحرافاً مميّزاً عن النسبة (1:1) حيث كانت نسبة الإناث (47.96%) والذكور (52.04%) أي أن كل 1 ذكر يقابله 0.92 أنثى. وتبين بعض الدراسات أن توزع الجنس عند الكائنات الحيوانية يعتبر صفة نوعية ويتغير تبعاً لظروف البيئة والمنطقة الجغرافية [14]، وهذه النتيجة مماثلة لنتائج دراسات سابقة [9]، [12]. استناداً إلى قيم معامل النضج (*GSI*) وإلى دراسة التغير في حجم البيضة، والمراقبة المباشرة لتطور الغدد التناسلية لأسماك *Capoeta trutta* في بحيرة تشرين، تبين أن عمر البلوغ الجنسي للإناث يبدأ في السنة الثالثة وللذكور في السنة الثانية، حيث أظهرت العينات بأن (68.75%) من الإناث قد نضجت في السنة الثالثة من العمر، بينما كانت نسبة الذكور الناضجة في السنة الثانية (76.92%) ولم يلاحظ أي عينة في الفئة العمرية الثالثة III غير ناضجة. حددت فترة التكاثر للأسماك في بحيرة تشرين اعتماداً على قيم معامل النضج (*GSI*) والمراقبة المباشرة لتطور المناسل وتحليل التغير والتطور الفصلي في قطر البيوض، حيث إمتد التكاثر من بداية شهر حزيران وحتى شهر آب. وكانت القيم الأعلى لمعامل النضج (*GSI*) في عينات حزيران، وكان هناك إنخفاض في القيم الوسطية في عينات الأشهر الباقية من العام، لأن معظم الأفراد كانت قد وضعت البيوض آنذاك، حيث لوحظ أن المبيض بعد التفريخ إنتقلت إلى الطور السادس والثاني من النضج وكان هناك عدد قليل من البيوض المتبقية في المبيض. وعلى ما يبدو أن حادثة إرتشاف (resorption) البيوض المتبقية في المبيض موجودة

خصائص التكاثر لدى أسماك *Capoeta trutta* (Heckel, 1843) في بحيرة تشرين (نهر الفرات)

لدى هذه الأسماك [15]، ثم إنتقلت المبيض الى الطور الثالث لتطور المبيض الذي إمتد من شهر كانون الاول وحتى شهر نيسان من العام الذي يليه، أما الطور الرابع فقد استمر حتى نهاية شهر أيار وانتهى بالطور الخامس في شهر حزيران. أن بعض أسماك المياه العذبة التي تتكاثر في الربيع والصيف يكون الطور الثالث من تطور مبيضها هو الأكبر طولاً والذي يكتمل في الربيع، أما الطور الرابع فيكون قصير عادة [14]، أن الشروط البيئية وخاصة التغذوية والحرارة تلعب دوراً هاماً في ديناميكية تطور البيوض والمناسل والدورة التكاثرية [14]. قدرت الخصوبة في (41) أنثى تم إمساکها قبل فترة التفريخ بقليل وكانت مبيضها في الطور الخامس  $V$  من النضج وقد تراوح عدد البيوض ما بين (9850-29884) بيضة، والقطر الوسطي للبيوض الناضجة ( $1.38 \pm 0.15$  mm)، أن حجم البيضة يتعلق بكمية الغذاء حيث أن الأنثى تقوم بهضم الطعام واستقلابه و ثم تخزين الغذاء في البيوض [3]. أما علاقة الإرتباط بين الخصوبة ( $F$ ) وكل من طول السمكة ( $FL$ )، وزنها ( $W$ ) ووزن الغدد المبيض ( $GW$ ) على التوالي: ( $r^2 = 0.67$ )، ( $r^2 = 0.65$ )، ( $r^2 = 0.72$ )، فقد كانت علاقة إيجابية ولكن العلاقة بين الخصوبة والطول كانت هي الأقوى مقارنة مع وزن الجسم ووزن المبيض، ولذلك فإن هناك إتجاه في زيادة أعداد البيوض بزيادة طول السمكة بشكل أكبر منه بزيادة وزنها ووزن مبيضها، هذه النتائج مشابهة لنتائج دراسات أخرى على هذا النوع. [9]، [12]، [13].

## The Reproduction Characteristics of *Capoeta trutta* (Heckel, 1843) fish in Tishreen Lake (Euphrates River)

Zouhir Ahmad Al-Majed and Maha Jad Chalfe

### Abstract

Biological reproduction has been studied in fish *Capoeta trutta*, in Lake Tishreen(Syria) through the identification of sex and age composition, age of sexual maturity, spawning, and reproduction period. Out of the 265 studied individual, the percentage of males and females were (%52.04) and (%47.96) respectively, which gives sex ratio of about (1:1). Samples were distributed in seven age (years) groups. Sexual maturity for males was reached in the second year where the percentage of males was (%76.92) by comparison the maturity of females was attained in the third year where the percentage of females was (%68.75). Based on the values and direct observation to gonadal development ( $GSI$ ) and eggs, the reproduction period occurred between June-August. The mean diameter of mature eggs was ( $1.38 \pm 0.151$  mm). Fecundity ranged between (9850-29884) eggs. relationship between fecundity ( $F$ ), length ( $FL$ ), body weight ( $W$ ) and ovarian weight ( $GW$ ) were: ( $r^2 = 0.67$ ), ( $r^2 = 0.72$ ), ( $r^2 = 0.65$ ) respectively.

**Keywords:** Age at first maturity, Spawning, Fecundity, *Capoeta trutta*, Tishreen lake.

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تنشر المجلة البحوث الأصلية التي تتوافر فيها  
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## قواعد وإجراءات النشر

- **اللغة:** تكتب البحوث باللغة العربية أو باللغة الإنجليزية ولا تستلم البحوث بغير هاتين اللغتين.
- **تقديم البحوث:** تقدم البحوث في أربع نسخ مطبوعة بفراغات مزدوجة وعلى وجه واحد، وهوامش حجم الواحد منها 2.5سم.
- يجب أن لا يزيد عدد صفحات البحث بما في ذلك الأشكال والرسوم والمراجع والجداول والملاحق عن (30) صفحة.
- يقدم الباحث ملخصين لبحثه في صفتين منفصلتين أحدهما باللغة العربية والآخر باللغة الإنجليزية في ما لا يزيد على 200 كلمة لكل منهما.
- يكتب عنوان البحث واسم المؤلف ورتبته العلمية والمؤسسة التي يعمل بها على صفحة منفصلة، ثم يكتب عنوان البحث مرة أخرى على الصفحة الأولى من البحث وعلى صفحة كل ملخص.
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- أسماء الأعلام الأجنبية: عند ورود أسماء أعلام أجنبية في البحوث المقدمة بالعربية فإنها تكتب باللغة العربية تليها الأسماء بالإنجليزية بين قوسين.

## التوثيق:

- أ- توثيق المراجع والمصادر المنشورة: يتم ذلك داخل المتن باستخدام نظام الترقيم [1] بين قوسين.
- تعد قائمة بالمصادر والمراجع المنشورة في نهاية البحث حسب الترقيم الوارد في النص.

إذا كان المرجع كتاباً يكتب هكذا:

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ب- توثيق الهوامش والمصادر غير المنشورة: يتم ذلك في المتن بإثبات كلمة (هامش) متبوعة بالرقم المتسلسل للهامش داخل قوسين، هكذا: (هامش1). وتذكر المعلومات التفصيلية لكل هامش في نهاية البحث تحت عنوان الهوامش وقبل قائمة المراجع:

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مراجعات الكتب: تقبل للنشر في المجلة مراجعات الكتب الحديثة القيمة.

التصرف: يحق لرئيس التحرير إجراء التغييرات التي يراها ضرورية لأغراض الصياغة.

المستلزمات: يمنح كل من ينشر بحثه نسخة واحدة من عدد المجلة الذي ينشر فيه البحث بالإضافة إلى عشرين مستلة منه.

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