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Assessing Microbial Pollution of Surface Water Streams at Thirty Villages in Gharbia and Menofia Governorates

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Abstract: The management of microbial pollution sources in rural surface water is challenging. Its management programs often rely on monitoring for a large number of water quality parameters to define contaminant issues. Total coliforms, faecal coliforms, and faecal streptococci have traditionally been used to identify microbial contamination. The objective of this study was to carry out an environmental survey based on the waste drainage systems and to assess the microbial pollution of rural surface waters in thirty Egyptian villages located at Gharbia (10 villages) and Menofia governerates (20 villages). The results show that septic tanks are the most common method of sanitary drainage systems in the Gharbia Governorate villages. About 60% of the villages had both of private net work and septic tanks systems and 30% had only septic tanks systems. In Menofia Governorate the dominant system is septic tanks which covered 85% of the surveyed villages. The municipal network was found under construction in about 15% of the villages. Statistical analyses of total coliform, faecal coliform and faecal streptococci demonstrated that the maximum microbial pollution was found in Ghrbia Governorate The averages of the TC, FC, and FS concentrations were $2.11x10^6$, $9.11x10^5$ and $9.93x10^4$ (MPN 100 ml^{-1}) respectively. While in Menofia Governorate, the averages of the TC, FC, and FS concentrations were $3.25x10^5$, $2.34x10^4$ and $1.75x10^3$ (MPN 100 ml^{-1}) respectively. The stream water in all of the thirty villages sites was identified as polluted, the specific location of the contamination source has not been identified and additional microbial source tracking (MST) methods will be required.

INTRODUCTION

Surface water streams can provide many benefits; they are the sources of water supplies for agriculture, individual properties, and industrial uses as well as providing recreational opportunities. The microbiological quality of surface is the principal factor in defining their acceptability for both drinking and other high contact activities(1).

Egyptian rural areas account for 56% of the population, but only have wastewater coverage of about 5%, more than 90% of

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the Egyptian rural-areas are not provided with wastewater collection and treatment facilities. There are about 4000 Egyptian rural-areas with a population ranging from 1000 to 20000 capita. The wastewater produced from houses in these rural areas is mainly treated in septic tanks. To meet the demands for water and wastewater services in the next decade, Egypt will have to invest US$ 5-7 billion, which is well above the available national resources. (2)

Providing rural areas in Egypt with water supply (more than 98% of rural areas in Egypt have water supply) has resulted in an increase of wastewater production, which increases the urgent need for proper facilities for wastewater collection and treatment(3).

Concern over agricultural diffuse pollution sources in integrated water quality management has been growing recently. All over the world, such sources are likely to be even more critical in developing countries, where agriculture and rural habitats are still dominant(4). With the introduction of intensive agriculture and adoption of modern farming techniques involving the application of much irrigation water and agricultural chemicals, the problems caused by diffuse agricultural pollution are bound to grow. Routine pollution control methods of discharge permits, EIAs or environmental audits, and normal enforcement measures by regulatory agencies are not likely to work for control of such pollution(5&6).

Pollution of freshwater resources is prevented through the enforcement of the laws, through public awareness programs and through a decrease in the land areas which are allowed to be cultivated with water-consuming crops. Freshwater supplies are augmented through irrigation improvement projects and the consequent cropping patterns; reuse of drainage water and recycling of treated water disposal and development of ground water resources(7).

In Egypt, the principle legislation

covering stream water is Law 48 for the year 1982[8] regarding Protection of Nile River and water courses from Pollution. In the application of the provisions of this law (Article 1), the following are considered waterways of the freshwater bodies:

1- Nile River, its tributaries and Akhwars.

2- Raiyahat, the canals with all its ranks and Gannabeyat.

Article (2) has stated that it is prohibited to discharge or cast the solid, liquid, or gas wastes discarded from real estate, shops, commercial, industrial and touristic facilities, or from sewage process in the waterways, either along the banks or over the surface unless after receiving license from the Ministry of Irrigation according to the regulations and standards stated in a resolution issued by the Minister of Irrigation based on a proposal by the Ministry of Health. In the Article 13 of the Law 48 for year 1982, the Nile Water Police Department shall supervise inspection patrols continuing along waterways and assist the competent authorities in controlling the wastes and in eliminating the causes of pollution and report any violation to the provisions of this law.

The assessment and management of microbial pollution, in particular, is an issue of great interest. Therefore, the government of Egypt is planning in the current 5-year plan (1997-2012) to increase wastewater networks and treatment capacity from 3.6 million m^3/day in order to raise the share of each citizen to 160 liters/day in cities and to 70 liters/day in villages through the establishment of more than 100 new treatment plants and networks in all governorates [9].

Egypt has a relatively well-established network of health facilities in rural and urban areas. It was one of the first countries in the area to create a comprehensive, nation-wide health system. However, despite some recent improvements in the incidence rates of some diseases and a high health-manpower/population ratio, most health indicators lag behind the standard prevailing in many developing countries(9).

The major health problems include endemic diseases such as gastro-intestinal diseases, diarrhea diseases, anemia, trachoma, chronic infections, and parasitic diseases(10). These problems are mainly a function of poverty, an unsanitary environment, the inappropriate distribution of health resources among the various regions and socio-economic groups, and limited government resources. While potable water is available to almost all the rural population, unsanitary disposal of liquid and solid wastes and inadequate personal hygiene are still major sources for dissemination and prevalence of infectious diseases(11).

Pathogens from infected humans and animals are added to surface waters through discharge of sewage, from agricultural activities and movements through soil. These sources produce a dynamic mix of diffuse and point source inputs(12).

Point sources of pollution are easy to identify and can effectively be controlled by the environmental laws that laid down for the protection of water(13&14). However, the diffuse sources of pollution are more important and serious in that they are difficult to assess and control(15).

The most common water-born bacterial pathogens are being *Salmlnella, Shigella*, *Staphylococcus aureus*, enterotoxigenic *Escherichia coli, Campylobacter*, *Vibrio,* and *Yersina*. Other pathogens occasionally found include *Mycobacterium, Pasteurella*, *Leptospira*, *Legionella*, and the enteroviruses (Poliovirus, echo virus and coxsakie virus), adinoviruses, reoviruses, rotaviruses, and the hepatitis virus A and E may also occure in water bodies(16).

Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, water is usually tested for faecal indicator bacteria. Although, they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoan that also live in human and animal digestive systems [(17)]. Members of two bacteria groups, coliforms and faecal streptococci, are used as the principal indicators of possible sewage contamination of natural water because they are commonly found in human and animal faeces in very large numbers [(18)].

Objectives of the study:

1- Carrying out an environmental survey based on the waste drainage systems.

2- Assessing the microbial pollution of rural surface waters in thirty Egyptian villages located at Gharbia and Menofia governerates.

Material and Methods

Environmental survey:

The study was done in the period from April 2005 to April 2006.

Thirty villages were randomly chosen on the Nile River branches at Gharbia Governorate (10 villages) and Monofia Governorate (20 villages) for collection of water samples.

The authors had carried out the environmental survey to evaluate the present status of the rural surface water for thirty villages in Delta region. Also, sanitary survey was identified to get the relationship between rural surface water microbial pollution and lack of sanitary services. A questionnaire sheet was designed to cover the environmental conditions in the villages.

Bacteriological analyses:

Five water samples were collected from the streams in each village for detecting bacteriological analyses. The samples were collected aseptically, starting from the most downstream location, in sterilized high-density polypropylene, wide-mouth, screw-capped bottles. The bottles were immersed in the tributary and filled to capacity while standing and holding the bottle on the downstream side. Care was taken to avoid disturbing the sediments as much as possible. Samples were collected, transported, and delivered to the High Institute of Public Health for laboratory examinations.

Detection of total coliforms, faecal coliforms, and faecal streptococci were carried out according to the Standard Methods for examination of water and wastewater[19].

Descriptive statistics were used to characterize the distribution of bacterial concentrations made at each sample location. Box and whisker plots were used to show the range of bacterial concentrations in stream water, the middle horizontal line of the box represents the median value while the whiskers show the range of the data. Relationships between mean microbial concentrations (dependent variables) were examined using the Pearson correlation coefficient. In this research, MINITAB package was used for statistical analyses[20]..

RESULTS AND DISCUSSIONS:

Results of Environmental Survey in Gharbia Governorate (10 villages) and Monfia Governorate (20 villages) :

In some villages located at Gharbia , the domestic wastes are discharged directly from houses into the stream water. Seurinck *et al.* [21] reported that resource problems are not so much environmental problems as they are people problems. Septic tanks are the most common method of sanitary drainage systems in the Gharbia Governorate villages. Figure (1) shows that about 60% of the villages (six villages; Shobra Babel, Kafr Hegazai, Alameria, Aldwaklia, Denosher, and Shobra, Malekan) had both of private net work and septic tanks systems. Private network (funded and operated by the villagers) did not cover all the villages' houses. Also, septic tanks systems were found in about 30% of the villages (three villages; Fiala, Alkamalia and Alsegaia). Only in one village (Saft Trab), the municipal network (designed, constructed, and operated under the supervision of municipalities) was found but till the end of the survey, the net work did not connect to the village' houses. As a result of the lack of control, some private contractors evacuated and discharged the septic tanks wastes into the surface water streams. Wastewater treatment plants are not found in the study villages except in Aldwaklia where there is one for serving El-Mahala El-Kobra city.

Figure (2) represents the situation of the sanitary drainage systems in Menofia Governorate. The dominant system is septic tanks which covered 85% (17 villages) of the surveyed villages. The municipal network was found under construction in about 15% of the villages (three villages; Shobra Bkhom, Arab Alraml, and Aghour Alraml). The wastewater treatment plant for those villages is located at Koiasna city.

It was noticed that the flow rates of fresh water in the surveyed streams was regularly decreased from south to north (Menofia to Gharbia) as a result of extensive agriculture activities. Meanwhile, the discharge of wastewater increased.

Results of Stream's water quality:

The principal parameters describing stream water quality were the concentration of the microbiological indicator species described in Table (1) & Table (2).

Many researchers have demonstrated that faecal indicator concentrations in surface water exhibit a log_{10} normal probability density function[22]. Thus, a geometric mean value was used as the measure of central tendency throughout the analyses presented below.

Tables (1) & (2) show the geometric mean concentrations of total coliform and faecal coliform which were used to describe bacteriological water quality in Gharbia and Menofia governorates during the study period.

Figures (3) and (4) plot the medians and the ranges of total coliform and faecal coliform concentrations for all 10 and 20 villages of Gharbia and Menofia governorates.

Total Coliform (TC) Concentrations in Gharbia Governorate:

During the research, Shobra Babel village showed the maximum GM (geometric mean) total coliform concentration which was $1.30X10^{7}$ (MPN/100 ml^{-1}) , and Alsegaia village had the minimum GM total coliform concentrations that was $1.30X10^{4}$ (MPN/100 ml^{-1}) as shown in Table (1). The average of the geometric mean for TC concentrations in all the 10 villages was $2.11x10^{6}$ (MPN/100 ml^{-1}).

Total Coliform (TC) Concentrations in Menofia Governorate:

Throughout the study, the maximum value of GM total coliform concentrations was $2.40x10^{6}$ (MPN/100 ml^{-1}) and it was detected in Shobra Bkhom and Met Elabsi villages , while Baksa village represented the minimum GM value and that was $9.10x10^{3}$ (MPN/100 ml^{-1}) as exhibited in Table (2). Also, as it is represented in the same table , the average of the geometric mean for TC concentrations in all the 20 villages was $3.25x10^{5}$ (MPN/100 ml^{-1}).

The results of ranges and medians of the concentrations of total coliform in both governorates is shown in Figure (3). Medians of $\log_{10}$TC concentrations in Gharbia and Menofia Governorates are 5.078 MPN/100 ml and 4.531 MPN/100 ml, respectively.

Faecal Coliform (FC) Concentrations in Gharbia Governorate:

It can be seen from Table (1), that Shobra Babel village represented the maximum GM value which was $1.5x10^{6}$ (MPN/100 ml^{-1}). This suggests that the stream was subjected to a high degree of faecal contamination during its passage. Alkamalia village gave the minimum GM value that was 1.50 $x10^3$ (MPN/100 ml^{-1}). As it is noted in table (1) the average of fecal coliform concentration is $9.11x10^5$ (MPN/100 ml^{-1}).

Faecal Coliform (FC) Concentrations in Menofia Governorate:

The maximum GM faecal coliform concentration observed in El- Menofia governorate was 1.5 $x10^5$ (MPN/100 ml^{-1}) detected at Shobra Bkhom village. Kafr Abdo had the minimum GM values of $2.65x10^3$ (MPN/100 ml^{-1}) as represented in Table (2). The average of the FC concentration was $2.34x10^4$ (MPN/100 ml^{-1}).

The results of ranges and medians of the concentrations of faecal coliform in both governorates is shown in Figure (4). Medians of log $_{10}$ FC concentrations in Gharbia and Menofia Governorates are 4.176 MPN/100 ml and 4.322 MPN/100 ml respectively.

Faecal Streptococci (FS) Concentrations in Gharbia Governorate:

As represented in table (1), Shobra Babel village represented the maximum GM value of (FS)which was $9.10X10^5$ (MPN/100 ml^{-1}) and Alkamalia village gave the minimum GM value that was 9.50 $x10^2$ (MPN/100 ml^{-1}) .Average of FS for all the 10 villages was $9.93x10^4$.

Faecal Streptococci (FS) Concentrations in Menofia Governorate:

The maximum GM faecal streptococci concentration observed in Menofia governorate was $1.15x10^4$ (MPN/100 ml^{-1}) detected at Shobra Bkhom village. Kafr Abdo had the minimum GM values of $1.20x10^2$ (MPN/100 ml^{-1}) as represented in table (2). Also, as it is represented in the same table, the average of the geometric mean for FS concentrations in all the 20 villages was $1.75x10^3$ (MPN/100 ml^{-1}). As it is shown in Figure (5), medians of log $_{10}$ FS concentrations in Gharbia and Menofia

Governorates are 3.792 MPN/100ml and 3.161 MPN/100 ml, respectively.

Table (3) represents the Pearson correlation coefficient (r) for the relationships between geometric mean of total coliform (TC), faecal coliform (FC), and faecal streptococci (FS) concentrations at the sampling points in Gharbia and Menofia governorates. Strong correlation (r) was found between faecal colifom and faecal streptococci in Gharbia governorate. (0.858 at $P< 0.001$), moderate correlation was found between TC and FC (0.75 at $P< 0.01$), also, between TC and FS (0.708 at $P< 0.01$), this may be occurred due to the inadequate monitoring of the stream sanitation which leads to the accumulation of solid waste on its bank length.

In Menofia Governorate, there is no significant correlation between TC, and betweenTC and FS. A strong correlation was noticed between FC and FS (0.925 at $p< 0.001$).

This suggested that the faecal pollution for the 10 villages of Gharbia was arising from the same source of pollution. Also, the strong relationship between faecal coliform and faecal streptococci in the 20 villages of Menofia Governorate was deriving from the same faecal contamination source. Crowther *et al* demonstrated the relationships between faecal indicator bacteria and the source of pollution in their research [22].

The results of bacterial analyses allowed us to locate two villages (Shobra Babel and Fiala) in Gharbia Governorate as chronically polluted stream water. In Menofia Governorate, three villages (Shobra Bkhom, Manshiat Elarab, and Met Elabsi) are considered chronically polluted because observed bacterial densities were excessive than the other sites. Considering the average of the total coliform, faecal coliform and faecal streptococci in both of the governorates, the microbial load has exceeded the acceptable level of contamination[23].

Nevertheless, there is no standard limit of bacterial indicators for the Nile River in Law 48 for the year 1982, even (Article 63) stated that the processed liquid industrial wastes licensed to be drained into freshwater bodies must not be mixed with human or animal wastes. Also, according to the (Article 65) of previous law stated that the drains water before being pumped into freshwater bodies should not contain more than 5000 MPN/100cm^3 of the potential number of the colonic group. Only, there is a standard limit in the (Article 69) for the fish traps water that it should not exceed (70) per 100 cm^3, and does not exceed (230) per 100 cm^3 in tenth of the samples taken from the lakes water at fishing season.

The results have suggested that stream water in Menofia Governorate has less degree of microbial pollution than in Gharbia Governorate. This may be due to the geographical location of the two governorates, as, Gharbia Governorate is located in North of Delta region and water quality tends to deteriorate down stream[24]. Also, this may refer to the heavy agricultural activities in that area and using uncontrolled amounts of fertilizers (manure and compost). The number of faecal indicator bacteria is generally higher for catchments with higher densities of septic systems compared to catchments which are serviced by municipal network [25].

Finally, the stream water in all of thirty villages was identified as polluted, the specific location of the contamination source has not been identified and additional microbial source tracking (MST) methods[26] will be required. Also, Kuntz *et al.,* reported the use of the targeted sampling protocol as a prelude to microbial source tracking[27].

Conclusions:

While the data from the thirty villages of Gharbia and Menofia governorates provide a general picture of the Nile River and its condition, they are not able to identify where the worst contamination occurs for effective conservation practice placement. It is better to identify where the worst microbial contamination originated. There can be no doubt that land use profoundly affects the quality of water in streams. It is becoming increasingly evident that to achieve the goals of the water quality management program, regulating and controlling only point sources is not sufficient.

Agricultural diffuse pollution of stream water is still a major problem in Egypt and world wide. The challenge associated with controlling such pollution arises from insufficient information of the relationships between water quality and agricultural land-use practices. They might also contribute to evaluating the likely effectiveness of possible strategies for improving the bacteriological quality of surface waters in rural catchments, through, for example, riparian buffer strips or other controls on land use and agriculture management practices.

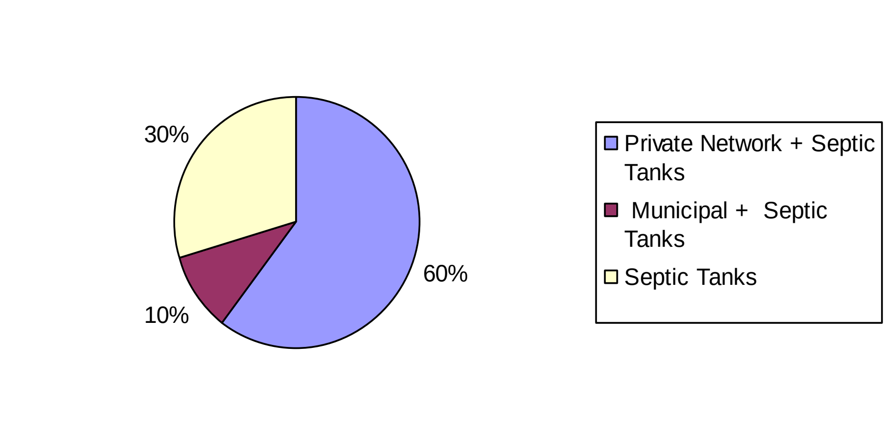


Figure (1) Sanitary drainage systems in 10 villages of Gharbia Governorate

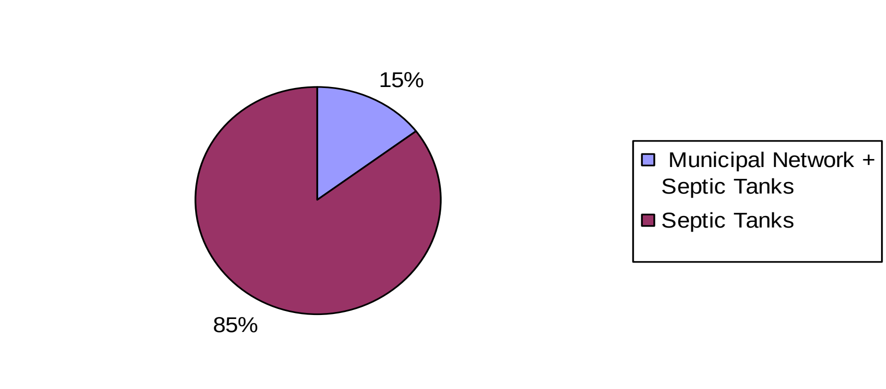


Figure (2) Sanitary drainge systems in 20 villages of Monifia Governorate

Table (1): Bacteriological Analysis of Surface Water in 10 Villages Located at Gharbia Governorate

Village Name	GM Total coliform*	GM Faecal coliform*	GM *Faecal streptococci*
Shobra Babel	$1.30X10^7$	$1.50X10^6$	$9.10X10^5$
Kafr Hegazai	$2.35X10^5$	$2.30X10^3$	$1.10X10^3$
Fiala	$7.00X10^6$	$7.50X10^5$	$4.80X10^4$
Alkamalia	$4.00X10^5$	$1.50X10^3$	$9.50X10^2$
Alameria	$9.30X10^4$	$4.10X10^4$	$3.20X10^3$
Aldwaklia	$4.30X10^4$	$2.60X10^3$	$1.75X10^3$
Alsegaia	$1.30X10^4$	$1.20X10^4$	$1.20X10^4$
Denosher	$2.10X10^5$	$1.50X10^4$	$8.50X10^3$
Saft Trab	$1.10X10^5$	$1.70X10^4$	$6.50X10^3$
Shobra Malekan	$1.30X10^5$	$1.55X10^4$	$5.90X10^3$
Average	$2.11x10^6$	$9.11x10^5$	$9.93x10^4$

* GM: Geometric mean MPN/100ml

Table (2): Bacteriological Analysis of Surface Water in 20 villages located at Menofia Governorate

Village Name	GM Total coliform*	GM Faecal coliform*	GM *Faecal streptococci*
Shobra Bkhom	$2.40x10^6$	$1.5x10^5$	$1.15x10^4$
Baksa	$9.10x10^3$	$9.10x10^3$	$4.50x10^2$
Manshiat Elarab	$1.10x10^6$	$2.00x10^4$	$1.65x10^3$
Met Elabsi	$2.40x10^6$	$1.50x10^4$	$1.15x10^3$
Arab Alraml	$4.30x10^4$	$3.60x10^3$	$1.23x10^3$
Aghour Alraml	$4.20x10^4$	$2.80x10^3$	$1.95x10^2$
Kafr Shekh Ibrahim	$4.40x10^4$	$2.70x10^3$	$1.88x10^2$
Kafr Abdo	$4.35x10^4$	$2.65x10^3$	$1.20x10^2$
Kafr Wahb	$4.38x10^4$	$2.84x10^4$	$1.16x10^3$
Manshiat Damalo	$9.30x10^4$	$3.60x10^3$	$2.75x10^2$
Um Khenan	$2.40x10^4$	$2.10x10^4$	$1.45x10^3$
Manshiat Um Khenan	$2.50x10^4$	$2.20x10^4$	$1.63x10^3$
Alagaiza	$2.30x10^4$	$1.90x10^4$	$1.25x10^3$
Kafr Zen Eldein	$2.80x10^4$	$2.30x10^4$	$1.80x10^3$
Kafr Alsalamia	$3.50x10^4$	$2.40x10^4$	$1.85x10^3$
Kafr Abshish	$3.20x10^4$	$2.70x10^4$	$2.11x10^3$
Shobra Kubala	$2.60x10^4$	$2.10x10^4$	$1.37x10^3$
Kafr Ashleem	$2.90x10^4$	$2.30x10^4$	$1.80x10^3$
Ashleem	$3.30x10^4$	$2.40x10^4$	$1.92x10^3$
Kafr Alarab	$3.00x10^4$	$2.60x10^4$	$1.85x10^3$
Average	$3.25x10^5$	$2.34x10^4$	$1.75x10^3$

GM: Geometric mean MPN/100ml

Table 3: Pearson correlation coefficients (r) for the relationships between geometric mean Total Coliform (TC), Faecal Coliform (FC) and Faecal Streptococci (FS) concentrations at the sampling points in the Gharbia (n = 10) and Menofia (n = 20) Governoratesa

	Gharbia Governorate	Menofia Governorate
TC and FC	0.750*	ns
TC and FS	0.708*	ns
FC and FS	0.858**	0.925**

[a] ns=not significant (p ≥ 0.05); **significant at p < 0.001; *=significant at p < 0.01

Figure (3): The Ranges and Medians of log_{10} Total Colifom Concentrations (MPN/100 ml) for Gharbia and Menofia Governorates

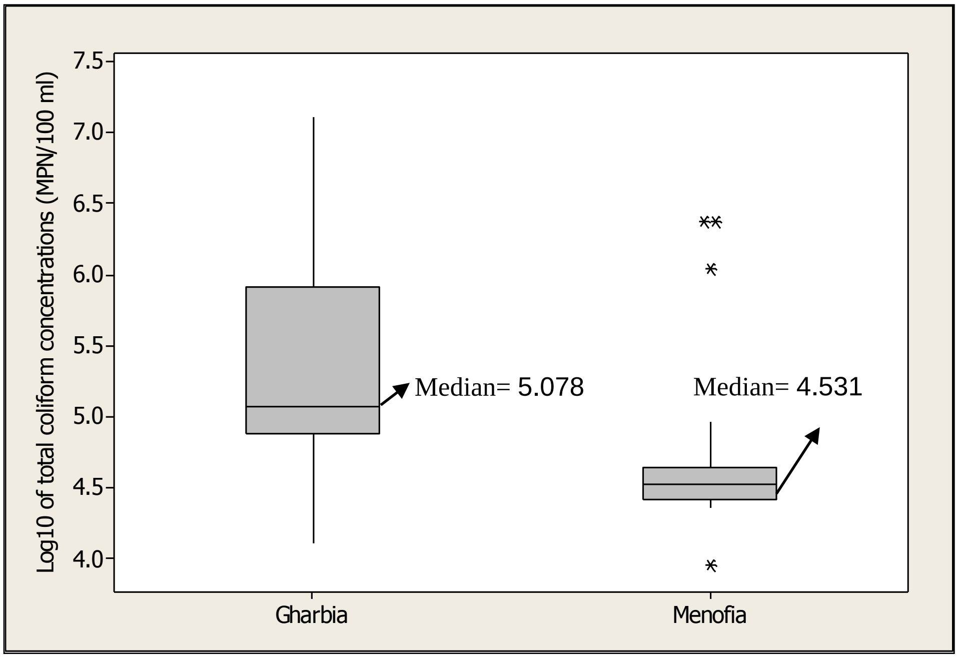


Figure (4): Ranges and Medians of $\log_{10}$ faecal colifom concentrations for Gharbia and Menofia Governorates

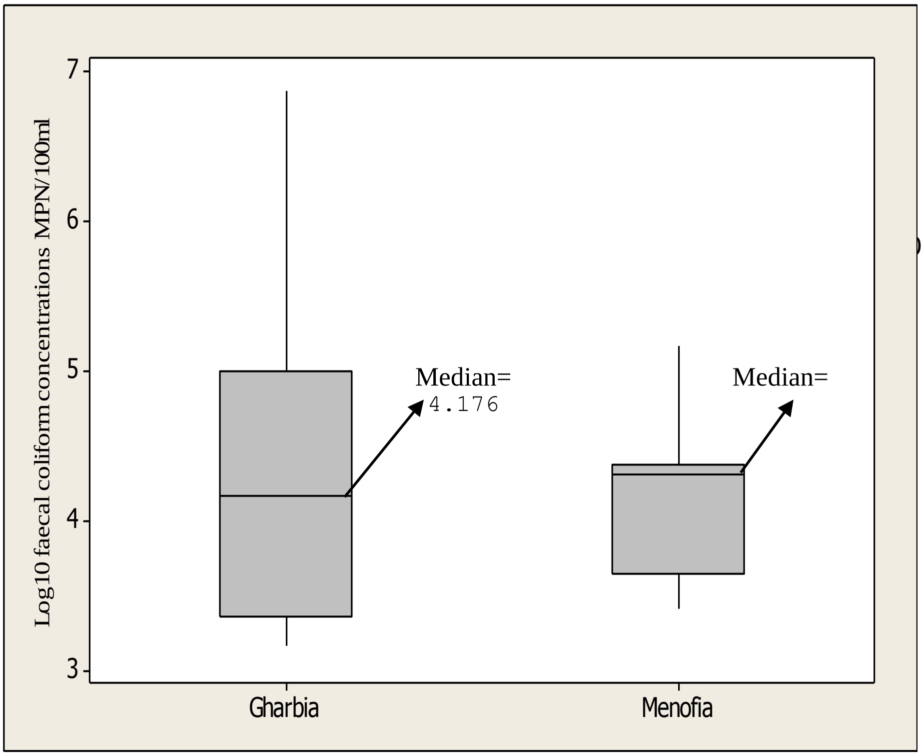
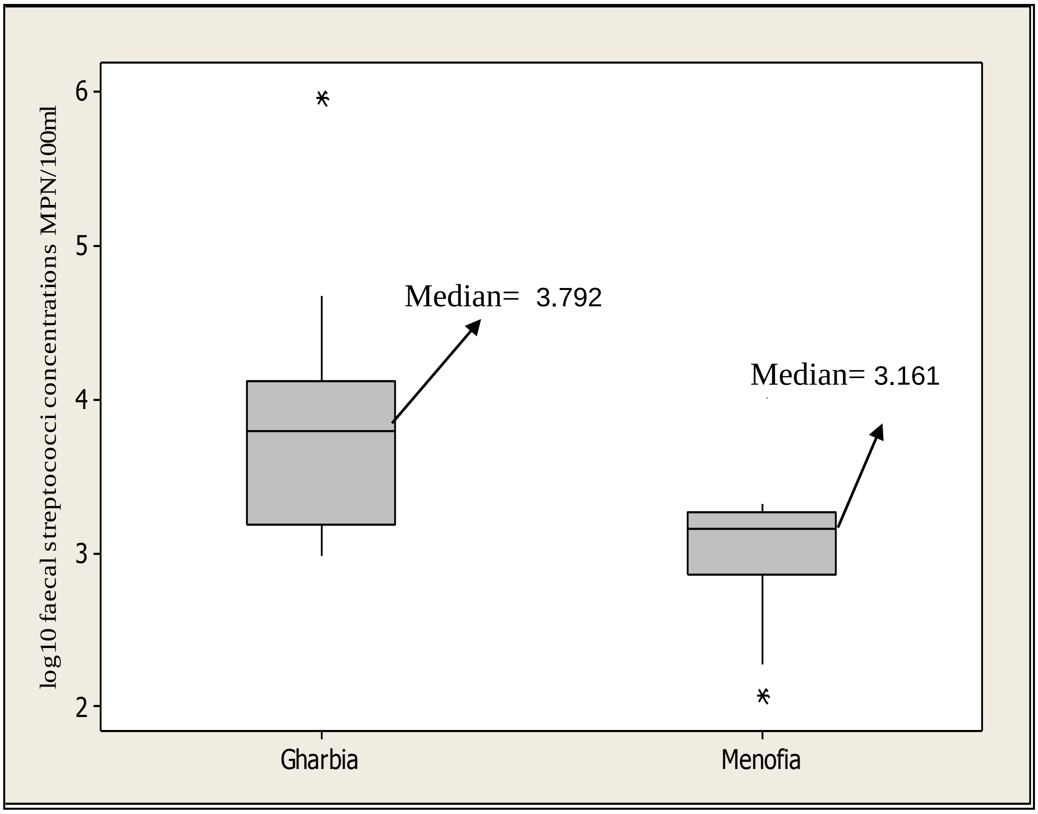


Figure (5): Ranges and Medians of log_{10} faecal streptococci concentrations for Gharbia and Menofia Governorates



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