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Occurrence and Distribution of Microbiological Indicator and Pathogens in Shallow Ground Water and Distribution System in Some Villages in Dakahelya Governorate

Aya Hakim *

* A.S.Hakim: Researcher of Microbiology, Manager of Microbiology laboratory, Central Laboratory for Environmental Quality Monitoring , CLEQM. National Water Research Centre, NWRC, El Kanater , Egypt.

Abstract

With increased generation and discharge of human, agricultural and industrial wastes, the potential for contamination of surface and ground water by harmful microorganisms is on the rise. Faecal pollution can introduce a variety of enteric pathogenic bacteria, viruses , and parasites , their presence is linked to microbial diseases. A total of twenty drinking water and ground water samples collected from four important villages (Belgay ,Gemiza Belgay, Ezbet Zeidan and Ezbet Salama Sleem) in Dakahlea Goveronorate were analyzed for microbiological indicators and *Salmonella* .Samples were collected from hand pumps and different houses to represent the quality of water, for this purpose several bacterial and chemical parameters were investigated ; including indicator bacteria such as , heterotophic plate count (HPC), total coliform, faecal coliform and *faecal streptoococci* as well as pathogenic bacteria *Salmonella* .

All the obtained drinking water except one result are in accordance to the local and International Standards for drinking water.

For ground water samples, all the results obtained from hand pumps were contaminated with total coliform, faecal coliform, faecal *Streptococci* and *Salmonella* microorganism, this may be attributed to the presence of the septic tank closed to water pipes. Faecal indicators concentrations are often elevated because of wastewater and combined sewer overflows. .Gemiza Belgay represents the most contaminated hand pump with Heterotrophic plate count (HPC) exceeding 800 at 22^{0}C and 500 CFU/ 1ml at 37^{0}C ml respectively, total coliform 40 CFU/100ml , faecal coliform 40 and faecal *streptoococci* was 20 CFU/100ml respectively. Presence of septic systems on the property near the sampling site and well depth were found to be related to detection of coliforms and pathogens in ground water. Land use was also found to have the most significant effect on concentrations of bacterial indicators and pathogens in shallow ground water.

Key words :

Microbiological monitoring, public health microbiology , pathogenic bacteria, indicator microorganisms, *Salmonella*.

Introduction

Drinking water safety is a worldwide concern and the contaminated drinking water has the greatest impact on human health worldwide (**Geldrich,1990**). Drinking non treated or improperly treated water is a major cause of illness in developing countries, for example, in 1980, 25,000 persons per day died worldwide as a result of consumption of contaminated water (**WHO 1979 and American Public Health Association, 1992**).

Drinking water is not sterile and the Public water supply has never intended to provide a sterile product. The microbial quality of potable water, is a reflection of those organisms introduced in source water, modified in composition through treatment processes, colonized in the distribution system, and selectively amplified in various attachment devices, while there may be significant differences in the microbial flora of some water supplies that impact on taste and odor . All safe water supplies either contain no organisms derived from the intestinal tract of warm blooded animals (faecal organisms) or from other sources are treated to minimize this risk to public health (**Geldreich,1990 and Gerba & Rose (1990**).

Microbiological examination of water is typically used to determine the sanitary quality of water and the public health risk from water borne disease. Contamination of natural waters by microorganisms directly affects public health because of the use of these resources for potable supply and recreation.

Natural waters may be an important vehicle for the transmission of enteric diseases, for this reason to test the sanitarv quality of these waters is necessary. The direct search for pathogenic microorganisms from water samples presents several problems, such as their low numbers and their intermittent presence, just to name a few, these disadvantages have led to the use of other microorganisms called indicators, which are easier to analyse, total and faecal coliforms (TC and FC) faecal *streptococci* (FS) are the classical indicators, however some studies reported the detection of several pathogenic microorganisms in absence or at low levels of these indicators (**Moringo et al.,1990 a**).

Salmonella are pathogenic bacteria , often detected in sewage, freshwater, marine water, and groundwater, *Salmonella* can survive for long periods in natural waters and the persistence of specific and epidemic strains is of great concern in public health. these serotypes may be good indicators of specific contamination sources.

Salmonella are ubiquitous enteric bacteria, these gram negative rods are the etiologic agents of food-borne salmonellosis and also the agent that cause typhoid and paratyphoid fever. Although food products, including shell fish are the most common sources of salmonellosis, *Salmonella* is a prime example of a water and shellfish – transmitted pathogen. *Salmonella* is a large genus of bacteria including more than 2,300 serotypes, and diagnosis in the majority of laboratories relies on costly and laborious culture screening with both non selective media. Nevertheless, only a limited set of serotypes are prevalent within clinical isolates. For instance, 15 serotypes of clinical origin accounted for 80% of the 22,100 isolates or data collected by the French Agency for Food Safety in 1998 , in contrast environmental isolates represented less than 4.4% of these isolates.

Both human and animal excreta are sources of *Salmonella*, and many potential routes are used for the transmission of these excreted enteric pathogens. The ability of *Salmonella* to be transmitted by any of these routes depends largely on its resistance to environmental factors, which control its survival, and its capacity to be carried out by water as it moves through the environment. Neverthelss, this survival capacity may depends on species and pollution sources. Although most studies have focused on the determination of *Salmonella* strain concentrations in some polluted areas, it was recently shown that the annual bacteria loads of this pathogen in rivers and coastal areas can be very important.

The relationship between results from the chemical and microbiological analysis not only indicates contamination from sewage but also provides information on contamination of seepage water and soil due to decomposition process in the under ground.

The objectives of this research were to (a) determine the sanitary quality of drinking water in distribution system in these villages in Dakahelya Governorate. (b) begin to describe the occurrence and distribution of selected microbiological pathogens and their indicators in aquifers in relation to human and factors that may affect the sanitary quality of water.

The present study was carried out in Dakahelya during summer of year 2006 to evaluate the quality of water in distribution system and "shallow Hand pump wells "ground water

Sampling Site Selection.

The samples were selected according to the specific objectives of the study, Samples were collected for microbiological and chemical analysis from 4 hand pump and 4 chlorinated samples from houses (Distribution system) during summer 2006 from the following villages in Dakahlea Goveronorate :

Belgay ,Gemiza Belgay, Ezbet Zeidan , and Ezbet Salama Sleem .

Sample collection

Samples were collected (duplicate) in sterile glass bottles and transported in ice boxes to the laboratory for bacteriological analysis (within 6 h) , sterile conditions were maintained during collection, preservation, storage, and analysis of distribution system and ground water for microbiological analyses. **Standard APHA 1995** technique was used for collecting drinking water. Existing wells were sampled by satisfying purging criteria as described in **Koterba et al(1995)**. The well was considered adequately purged after at least three casing volumes were removed and values of pH, temperature , specific conductance, dissolved oxygen, and turbidity had stabilized, this purging ensures that the sample collected reflects the characteristics of

the water in the aquifer and not that of the water that had been standing in the well .All samples were collected directly from the tap into a sterile container. Samples were obtained by use of peristaltic pump with autoclaving silicon tubing.
In addition to monitoring for microbiological indicators , field personnel measured water quality characteristics were done.

Methods

Physicochemical analysis .

The following parameters were measured in all water samples ; temperature, electric conductivity, pH, ,total dissolved solids, major cations, anions and trace metals.

Bacteriological analysis

All water samples used in the present investigation were subjected to analysis for the following bacteriological parameters:

Heterotrophic Plate Count (HPC) , Total coliform (T.C), faecal coliform (F.C) and faecal *streptoococci* (F.E), as well as *Salmonella*, with the exception of total HPC , all other bacterial parameters were examined by using the membrane filter technique. All bacteriological media used through this study were prepared according to **Difco Manual, (1985)**. While the procedures followed for the detection of different bacteriological parameters, were described according to the Standard Methods for Examination of Water and Wastewater (**APHA, 1995**).

The heterotrophic plate count was performed at 22^0C and 37^0C on 1 ml of water. The total coliforms on endo-agar LES, faecal coliforms on m-FC agar, and faecal *Streptococci* on m-enterococcus agar as recommended. *Salmonella* count was evaluated on tetrathionate broth then on bismuth sulfite agar and XLD.

Isolation of *Salmonella*.

Samples were collected in sterile flasks and analysed within 6 h after sampling . *Salmonella* are present in natural waters at low concentrations within a more or less important background of other bacterial genera depending on the type of water (river or wastewater) .For river and ground water samples , *Salmonella* was isolated after pre-enrichment in tetrathionate broth at 37^0C for 24 h., then selective enrichment (bismuth sulfite , brilliant green agar and XLD) were used.
Typical colonies of *Salmonella* were confirmed by biochemical tests. Isolates were tested for their inability to produce oxidase (oxidase test; Difco), their ability to produce H_2s and degrade 4-methylumbel liferyl capriate, and their ability to oxidize and ferment lactose.

Results and Discussion

The pollution of ground water in the Nile valley and the Delta may occur at points, such as septic tanks and poorly sealed hand pumps or wells, or linearly from drainage ditches. Pollution is also caused by excessive fertilizer use and animal manure. For instance , most of the nitrogen fertilizer applied to fields converts to nitrate in the soil. Since nitrate is highly soluble in water and very mobile , a large portion of it may leach into groundwater system.

Belgay Village

The results presented in Table (1) showed that heterotrophic bacterial counts in the samples represented the distribution system recorded zero in 22^0C and 37 ^{0}C CFU/ml respectively, sample was free of bacterial indicators total coliform, faecal coliforms and faecal *streptococci* ,this results agree with the local and international standards of drinking water,that stated that all the examined samples should be free of indicator bacteria and the heterotropic count should not exceed than 50 CFU/ml.

Regarding to the hand pump sample represented the groundwater taken from the same village was highly contaminated, the heterotrophic plate count at 22^0C recorded 30 CFU/ml and 80 CFU/ml 37^0C respectively, total coliform recorded 16 CFU/100ml,faecal coliform 2 CFU/100ml while faecal *Streptococci* recorded 2 CFU/100ml.These results indicates bacterial contamination in the ground water that exceed the permissible limits for drinking water.

Sample taken from Belgay village was free of *Salmonella* organism in all samples either in distribution system or hand pump.

Gemezet Belgay Village

The samples represented the distribution system in Gemezet Belgay were free of bacterial indicator and heterotrophic plate count in 22^0 and 37^0C , the drinking water sample is potable for drinking and meet the local and international standards.

On the other hand sample represented the hand pump was highly contaminated ,with Heterotrophic plate count at 22^0C 800 CFU/ml, and 500 CFU/ml at 37^0C, total coliform registered 40 CFU/100ml , faecal *streptococci* 20 CFU/100ml , *Salmonella* was detected in the sample, that indicates the deterioration of water quality in the ground water.

Zidan Village

The samples represented the distribution system in Zidan village were free of bacterial indicator and heterotrophic plate count in 22^0C and 37^0C , the drinking water sample is potable for drinking and meet the local and international standards.

Regarding to the hand pump revealed bacterial contamination also, with heterotrophic plate count, 250 CFU/ml and 100 CFU/ml at 22^0 C and 37^0C respectively, while total coliform reached 230 CFU/100ml, faecal coliform 20 CFU/100ml, faecal *streptococci* 3 CFU/100ml. *Salmonella* was detected in Zidan village indicating faecal contamination.

Salama Sleem Village

Ezbet Salama Sleem represents the worst condition among all sources of pollution, drinking water sample represented the distribution system was highly deteriorated from the bacteriological point of view, Heterotrophic plate count registered 50 CFU/ml at 22^0 C and 30 CFU/ml at 37^0 C respectively, there were remarkable variation in total coliform that reached 600 CFU/100ml , faecal coliform 16 CFU/100ml, faecal *streptococci* 35 CFU/100ml respectively, *Salmonella* was detected in the sample represented the distribution system, However ,these results are not in compliance with drinking water standards. For the hand pump water sample ,heterotrophic plate count reached 50 at 22^0 C and 50 CFU/ml and 30 at 37^0 C. Total coliform count reached 410 CFU/100ml, faecal coliform recorded16 CFU/100ml ,and faecal *Streptococci* recorded 20 CFU/100ml. *Salmonella* was detected in Ezbet Salama Sleem in both distribution system and hand pump

Generally ,the results obtained and represented in table (1) and showed that heterotrophic bacteria was obviously higher when enumerated at 22^0 C than at 37^0C . The well with greatest concentrations of total viable count at 22^0C recorded (800 CFU /ml) at hand pump of Gemiza Belgay and (500 CFU /ml) at 37^0C .
Total coiforms, faecal coliforms , and faecal *streptococci* were detected in100 % of ground water samples. The greatest median concentration found was for total coliforms, and the lowest median concentration found for faecal *streptococci*. The greatest concentration of total coliforms (410 CFU/100 ml) was found in Ezbat Salama Sleem at a site that is significantly affected by sewage.
The greatest concentration of faecal coiforms (25 CFU/100ml) was detected in Gemiza belgay and for faecal *streptococci* the highest count was found also in a sample collected from Ezbet Salama Sleem and Gemiza Belgay ,where faecal indicator concentrations are often elevated because of wastewater and combined sewer overflow.

Total coliforms were detected in all four study hand pump wells, indicating possible faecal contamination. Presence of septic systems on the property near the sampling site and well depth were found to be related to detection of coliforms and pathogens in shallow ground water. Land use was found to have the most significant effect on concentrations of bacterial indicators in stream and canal water.
Faecal indicator concentrations are often elevated because of wastewater and combined sewer overflows.The ratio of faecal coliform organisms to faecal *Streptococci* (< 3:1) indicates human wastes and a ratio of (> 0.7 :1) indicates that the source is other animal wastes, this indicator is useful in location the origin of faecal pollution in heavily contaminated sources of untreated water, provided sufficient data are collected.

Our results are in accordance with those obtained by (**Moringo et al 1990 a)** who reported that, there is a significant relationship between indicator microorganisms level and *Salmonella* in water which influenced by faecal discharge.

Chemical analysis

Chemical analysis of water samples was performed to make ensure that the level of the different minerals are within the limits of the Egyptian Standard of chlorinated drinking water samples.

Tables (2 , 3 ,4 and 5)) represent the chemical analysis of water samples collected from different treatment plants and different houses. The level of different minerals of water samples within the limits of the Egyptian Standard. However, for Manganese. It exceeds the permissible level of the standard. This may be due to the high concentration of the element in ground water in this area.

The problems associated with chemical constituents arise primarily from their ability to cause adverse effects after to cause adverse effects after prolonged periods of exposure of particular concern are cumulative poisons and carcinogens. There is either direct or indirect evidence that all of the substances can cause harmful effects and are known to occur in water.Contaminants can enter a potable water distribution system through cross-connection, back-flows, breakage, and leaks or they may result form materials used in the construction of the system.

pH, the pH value is approximately 8.5;which is considered moderately alkaline. It seems that this pH value is affected by a number of factors as the well often contains loads of organic matter and nutrient salts, the overall assessment of pH values did not exceed the permissible limits of **Law (48 / 1982)**, as most values were between 7.5 to 8.6 mg/l

Conductivity varied from 0.441 mmhos/cm to 3.08 mmhos /cm in Gemiza Belgay during July.

Total dissolved solids (TDS) ranged between 285.0 mg/l to 1971mg/ L in Gemiiza Belgay

Total alkalinity ranged from 173 mg/L in drinking water in Ezbet Belgay to reach the maxaimum 621.2mg/L in Gemiza Belgay hand pump.

Ammonia concentrations were as high as 2.39in Gemiza Belgay, while the lowest recorded concentration was <0.2, The high levels are believed to be a result of direct discharge of domestique wastes which enhances chemical reaction producing ammonia.

Nitrites were present in minor quantities along the period of study, their presence are considered unstable form ammonia and nitrate as a result of oxidation or from nitrate to ammonia by reduction.

Nitrate values did not exceed the permissible limits of law 48 /1982

Manganese values did not exceed the permissible limits except in Gemiza Belgay it reach its maximum 0.28 mg/l.

Drinking water standards

The Minister of Health issued ministerial Law 108/1995 for drinking water standards. The bacteriological standards are as follows:

- Total bacterial count should not exceed 50 colony forming unit one cubic centimeter at 37°C for 24 hour incubation period or at 22°C for 48 hours.
- Total coliform must be absent in 95 percent of all water samples examined samples should contain more then 3 coliform/100ml ,and this level should not appear in two consecutive samples .

All water samples examined must be free from faecal coliflorm organisms and faecal *streptococci.*
This standards went to effect into March 1995.

Conclusion

The present investigation was devoted to determine the quality of drinking water (distribution system) and ground water (hand pump) in four villages in Dakahelya Governorate namely ; (Belgay, Gemiza Belgay, Ezbet Zeidan and Ezbet Salama Sleem).

- The obtained results demonstrated that all water treatment plants except one represented in Ezbet Salama Sleem distributed finished water that was essentially free of indicator and pathogenic bacteria, these results are in accordance to the local and International Standards for drinking water.
- For ground water samples , all the results obtained from hand pumps were contaminated with total coliform, Faecal coliform, faecal *Streptococci* and *Salmonella* microorganism, this may be attributed to the presence of the septic tank closed to water pipes. Faecal indicators concentrations are often elevated because of wastewater and combined sewer overflows .
- Gemiza Belgay represents the most contaminated hand pump with heterotrophic plate count (HPC) exceeding 800 at 22°C and 500 CFU/ 1ml at 37°C ml respectively, total coliform 40 CFU/100ml, faecal coliform 40 and faecal *streptoococci* was 20 CFU/100ml respectively. Presence of septic systems on the property near the sampling site and well depth were found to be related to detection of coliforms and pathogens in ground water.
- The present investigation concluded that the hand pump (ground water) are suffering from extreme pollution concerning both physico, chemical and bacteriological characteristics.

A safe and reliable water supply is certainly of prime importance for community health. However, the successful implementation of a safe drinking water and effective sanitation programme in developing countries is not a simple process. Three major elements are involved : Protection of water resources, change in people's behaviour in collecting and using water, and expanded use of latrines. Each intervention calls for public health education, technical expertise, and parallel development of human resources and infrastructure. Furthermore, an evaluation of previous development projects and water quality monitoring by practical methods would help to promote community health goals.

Since women and children are involved most water collecting activities, their participation in public health education programmes, organized by community based primary health care workers, is essential to eliminate unhygienic water collection and promote healthy behaviours. This approach could have a notable impact in the cultivated area.

For ground water samples, a greater diversity of lithologics, aquifer types, and land-use categories among study units would be needed to adequately assess the relationship between detections of microbiological indicators and other factors. Other factors not investigated in this study and worth investigating in future studies include population densities and soil drainage properties. Presence of septic system on the property and well depth were found to be related to detections of total coliforms in ground water, although these relationships were not statistically significant information about the direction of groundwater, flow from septic tanks and feedlots may help identify which wells are more vulnerable to contamination.

Future studies should focus on determining microbilogical water quality in wells categorized as single-family domestic, community ,or non-community well. This would help determine the extent to which current regulations are effective in the assessment of ground water quality and whether modifications to current regulations are needed to adequately protect public health.

Recommendation for water quality management to pathogens;

The following actions and water management practices will ensure the Egyptian waters meet the published criteria for pathogens-safe water.

- Treat wastewater at the source to prevent pollution of the waterways and water bodies.
- Enforce law # 48/1982 and its standards.
- Regularly monitor water quality and wastewater discharges throughout waterways.
- Develop a public educational campaign to disseminate information on water quality, uses availability needs and hazards.

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Table(1) Bacteriology analysis of some villages in Dakahelya Governorate

Results of bacterial analyses of some Villages in Dakahelya Governorate									
Parameters		Belgay		Gemezet Belgay		Zidan		Salama	
		Dist. System	hand pump	Dist. System	hand pump	Dist. System	hand pump	Dist. System	hand pump
Heterotrophic plate count 22°C	CFU/1ml	0	80	0	800	0	250	250	50
Heterotrophic plate count 37°C	CFU/1ml	0	30	0	500	0	100	150	30
Total coliform bacteria	CFU/100ml	0	16	0	40	0	230	600	410
Fecal coliform bacteria	CFU/100ml	0	2	0	25	0	20	16	5
Fecal streptococci	CFU/100ml	0	2	0	20	0	3	35	20
Salmonella		(-ve)	(-ve)	(-ve)	(+ve)	(-ve)	(+ve)	(+ve)	(+ve)

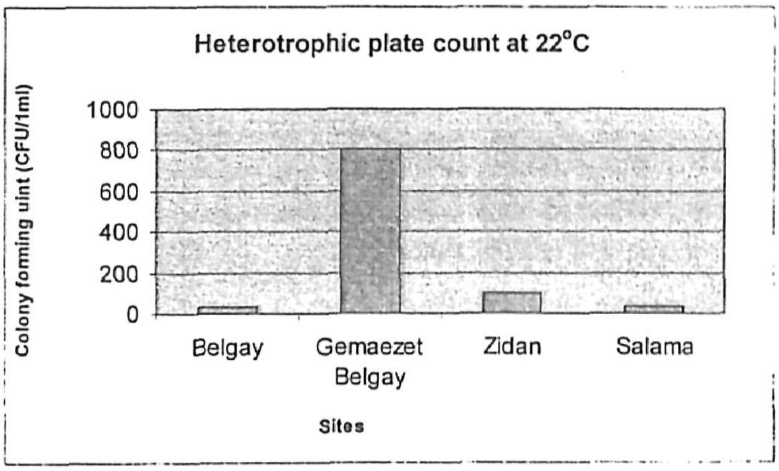

Figure (1) Heterotrophic plate count at *22°C*

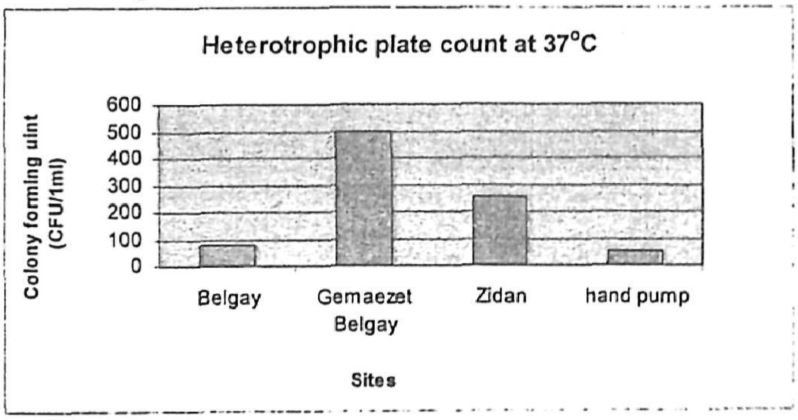

Figure (2) Heterotrophic plate count at *37°C*

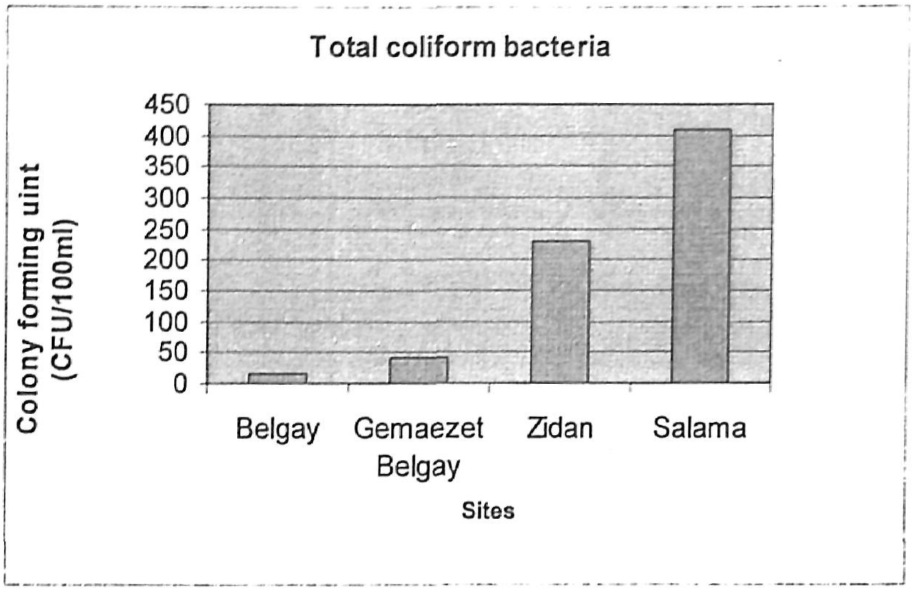

Figure (3) Total coliform

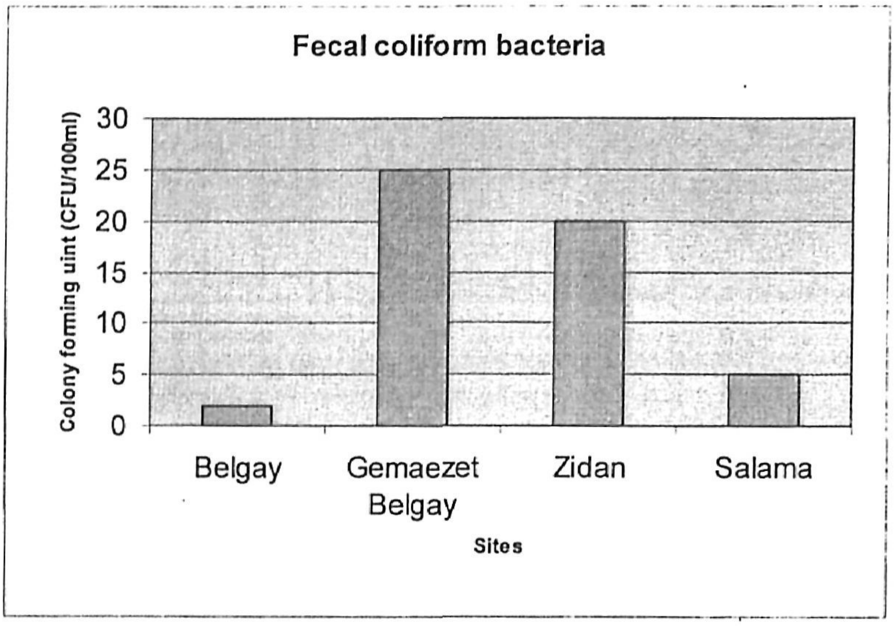

Figure (4) faecal coliform

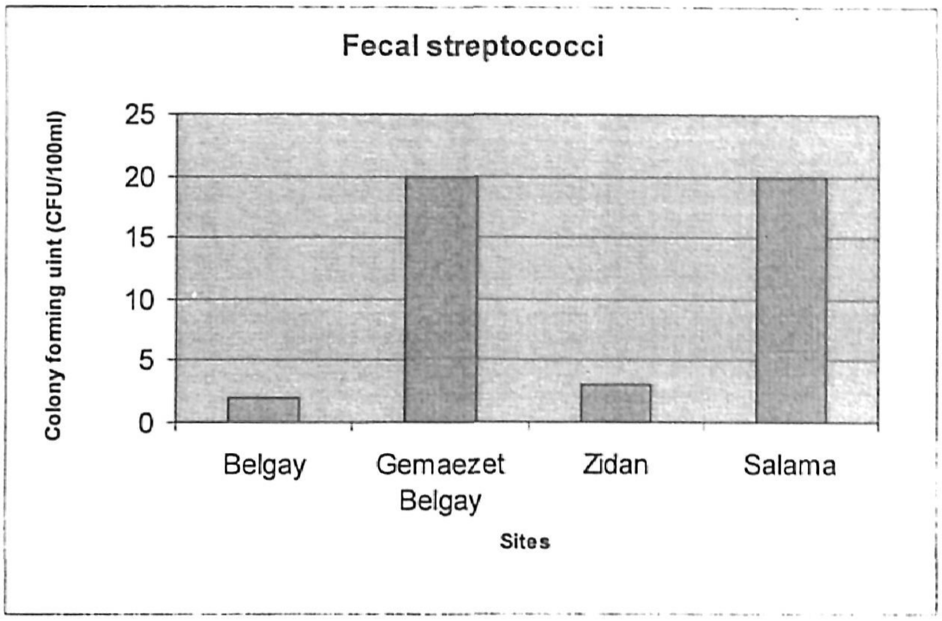

Figure (5) faecal Streptococci

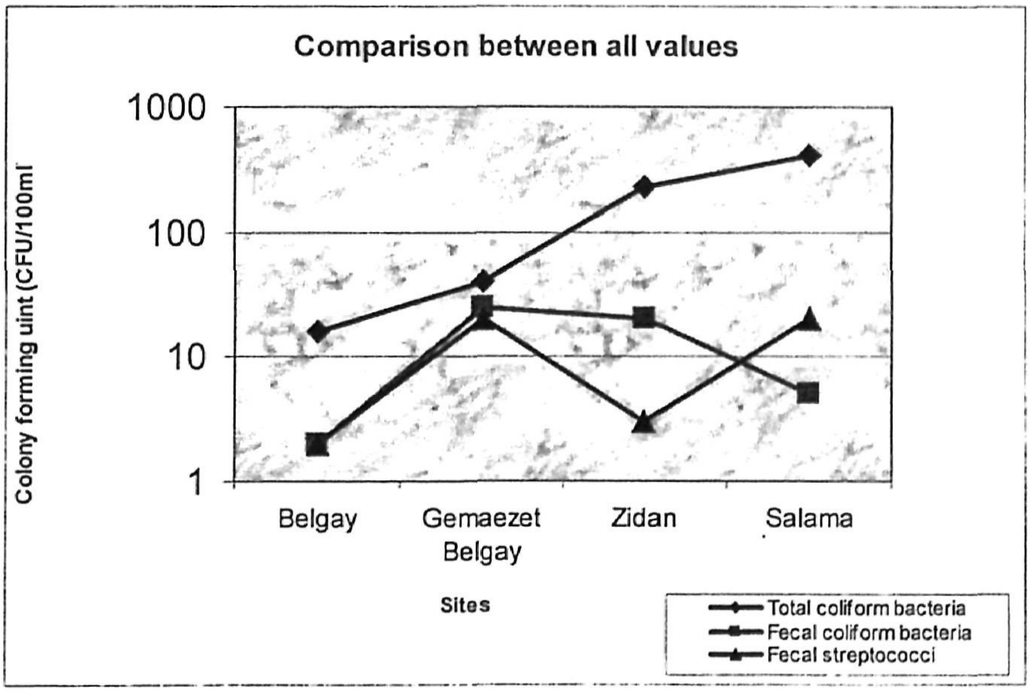

Figure (6)Comparison between all values

Table (2) Physicochemical Parameters

Sample code		Belgay		Gemaezet Belgay		Zidan		Salama		(WHO)	Law 108/1995
		Physicochemical Parameters									
PH	-----	7.54	8.37	7.78	8.32	7.84	8.61	7.76	8.57	6.5 - 8.5	6.5 - 9.2
Carbonate CO_3	mg/l	0.0	24	0	60	0	24	0	36	—	—
Bicarbonate HCO_3	mg/l	173.0	390.4	178	561.2	184	292.8	180	280.6	—	—
Total Alkalinity	mg/l	173	414.4	178	621.2	184	316.8	180	316.6	—	—
Electrical Conductivity (EC)	mmhos/cm	0.441	1.268	0.451	3.08	0.448	0.69	0.455	0.878	—	—
Total Dissolved Solids TDS)	mg/l	285.0	818	292	1971	289	447	294	566	1000	1200
Ammonia (NH_3)	mg/l	0.34	<0.2	<0.2	2.39	<0.2	1.024	0.34	0.68	1.5	—

Table (3) Major Cations

Sample code		Belgay		Gemaezet Belgay		Zidan		Salama		(WHO)	Law 108/1995
		Major Cations									
Calcium Ca	mg/l	30.8	55.8	31.2	118	29.7	45.6	32.4	50.3	—	200
Potassium K	mg/l	12.9	17.8	11.4	28.4	13.4	12.2	10.58	16.72	—	—
Magnesium Mg	mg/l	18.8	35.4	19.1	56.5	18.77	30.4	18.4	33.6	—	150
Sodium Na	mg/l	24.3	142	26.4	420	25.8	36.4	27	42	—	—

Table (4) Major Anion

Sample code		Belgay		Gemaozet Belgay		Zidan		Salama		(WHO)	Law 108/1995
		Major Anions									
Chloride Cl	mg/l	33.70	176.95	35.40	592.15	31.50	41.72	36.30	49.32	250	500
Nitrite NO_2	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	—	—
Nitrate NO_3	mg/l	0.68	0.31	0.85	<0.2	0.63	<0.2	0.87	<0.2	10	10
Phoshate PO_4	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	—	—
Sulfate SO_4	mg/l	30.70	26.62	30.78	110.00	31.50	5.96	32.3	5.706	400	400

Table (5) Trace Metals

Sample code			Belgay		Gemaezet Belgay		Zidan		Salama		(WHO)	Law 108/1995
Trace Metals												
Aluminum	Al	mg/l	0.143	0.034	0.057	0.033	0.041	0.033	0.05	0.03	0.2	0.2
Arsenic	As	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.05
Barium	Ba	mg/l	0.06	0.067	0.064	0.105	0.066	0.06	0.07	0.06	----	----
Cadmium	Cd	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.005
Cobalt	Co	mg/l	0.028	0.029	0.029	0.029	0.029	0.028	0.03	0.03	----	----
Chromium	Cr	mg/l	0.044	0.044	0.044	0.045	0.044	0.045	0.04	0.04	0.05	0.05
Copper	Cu	mg/l	0.039	0.035	0.031	0.03	0.033	0.033	0.03	0.03	1	1
Iron	Fe	mg/l	0.116	0.041	0.018	0.049	0.028	0.047	0.03	0.05	0.3	0.3
Manganese	Mn	mg/l	0.098	0.038	0.031	0.28	0.032	0.033	0.03	0.04	0.1	0.1
Molybdenum	Mo	mg/l	0.027	0.025	0.026	0.026	0.027	0.026	0.03	0.03	----	----
Nickel	Ni	mg/l	0.022	0.022	0.022	0.024	0.023	0.022	0.02	0.02	----	----
Lead	Pb	mg/l	0.046	0.044	0.045	0.045	0.047	0.056	0.05	0.05	0.05	0.05
Antimony	Sb	mg/l	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	----	----
Selenium	Se	mg/l	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.01	----
Tin	Sn	mg/l	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	----	----
Strontium	Sr	mg/l	0.085	0.066	0.17	0.222	0.105	0.083	0.10	0.05	----	----
Vanadium	V	mg/l	0.042	0.04	0.041	0.04	0.041	0.039	0.04	0.04	----	----
Zinc	Zn	mg/l	0.056	0.041	0.038	0.149	0.043	0.038	0.04	0.04	5	5