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Assessment of Physicochemical parameters of Freshwater and Tap Water in Suez Canal Region, Egypt

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Abstract

The objective of this study was to monitor the freshwater quality in Suez Canal region, Egypt and to determine the efficacy of water treatment system in the removal of contaminates. The hydrographic parameters recorded were air and water temperatures, pH, electric conductivity (EC), turbidity, alkalinity, dissolved oxygen content (DO), chemical oxygen demand (COD), total dissolved solids (TDS), nitrate, nitrite, ammonium and phosphates. All measured physicochemical parameters of fresh water samples are within the acceptable limits except chemical oxygen demand (COD) is above the acceptable limits but all measured physicochemical parameters of treated (tap) water samples are within the acceptable limits.
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Keywords: Fresh and tap water, Suez Canal region; Physicochemical parameters

1. Introduction

Access to safe drinking water is important as a health and development issue at a national, regional and local level. The quality of water may be described in terms of the concentration and state (dissolved or particulate) of some or all of the organic and inorganic material present in the water, together with certain physical characteristics of the water. It is determined by in situ measurements and by examination of water samples on site or in the laboratory. The main elements of water quality monitoring are, therefore, on-site measurements, the collection and analysis of water samples, the study and evaluation of the analytical results, and the reporting of the findings. The results of analyses performed on a single water sample are only valid for the particular location and time at which that sample was taken. One purpose of a monitoring programme is, therefore, to gather sufficient data (by means of regular or intensive sampling and analysis) to assess spatial and/or temporal variations in water quality.

Water quality can be described by a single variable or by any combination of more than 100 variables. For most purposes, however, water quality can be adequately described by fewer than 20 physical, chemical and biological characteristics. The variables chosen in a monitoring programme will depend on the programme objectives and on both existing and anticipated uses of the water. Drinking and domestic consumption, agricultural irrigation, livestock watering, industrial uses and recreational use all require water of a specific quality.

Selecting the variables to include in a monitoring programme will often require a compromise

between "like to know" and "need to know" **(Bartram and Balance, 1996).**
Internationally World health organization (WHO) has published guidelines for water quality monitoring **(Bartram and Balance, 1996)** including all the requirements for establishing a water monitoring programme, principles of sampling , containers used for sampling and standard methods of analysis also WHO had published guidelines for drinking-water quality **(WHO, 2011)**. United States environmental protection agency (EPA) also is one of the most important organizations dealing with water quality had published guidelines for drinking water standards and health advisories. The American public health association (APHA) is the oldest and most diverse organization of public health professionals in the world and has been working to improve public health since 1872 AD and had published an important reference known as standard methods for the examination of water and wastewater which is used world wide as a reference for water analysis.

The guidelines describe a quality of water that is acceptable for lifelong consumption. A guideline value represents the level of a constituent that ensure pleasing water without results in any significant risk to the health of the consumer.

In Egypt, The Egyptian ministry of health (EMOH) is the authority responsible for guarantying the drinking water quality. Egyptian standard specifications for drinking water (ESSDW) are regulated by the minister of health decision number 458/2007. It includes physical, chemical, microbial and radiological upper limits that must not be exceeded in water for drinking purposes. Fresh water standards are regulated by the Egyptian law number 48/1982.

The literature survey reveals that several studies were done for water quality monitoring of Ismailia water canal **(Abdo et al., 2010)** but almost no studies had been carried out for water quality monitoring in the area of Suez Canal region.

In the current study a fixed routine was used which involve making all of the samples collection and field measurements within a three hours period around mid-day.

The hydrographic parameters recorded were air and water temperatures, pH, electric conductivity (EC), turbidity, alkalinity, dissolved oxygen content (DO), chemical oxygen demand (COD), total dissolved solids (TDS), nitrate, nitrite, ammonium and phosphates. All of these parameters were determined according to 21st Edition (APHA, 2005) **(Greenberg et al., 2005).**

2. Experimental

2.1. Sampling

Twenty-two water samples were collected from both fresh water and treated water from the selected sites described at Fig. 1 (a-c) during the research period from May-2008 to Feb-2011. These samples were collected at approximately 15-20 cm below the water surface. Treated water samples were collected from tap water after allowing water to flow for about 10 minutes to ensure representative samples. Samples were collected in polyethylene bottles pre-washed three times with tap water, once with chromic acid, three times with tap water, once with 1:1 nitric acid, three times with distilled water in that order and they were further rinsed with sample water before collection.

Portable field meters were used to record temperature, pH, dissolved oxygen and conductivity of the surface water at the time of sampling itself. Water samples were obtained and stored in ice box for immediate determination of other hydrographic parameters at the laboratories of the Faculty of Pharmacy, Suez Canal University.

2.2. Physical examination of freshwater

2.2.1. Air and water temperature

Air and water temperature in degree celcious (°C) was measured using a glass mercuric thermometer 110 °C with 0.5 °C graduation intervals. The thermometer was dipped in water at a depth of 15- 20 cm for about 5 minutes. And the reading was then recorded. This was repeated three times, and the mean value was calculated.

2.2.2. Concentration of hydrogen ion (pH)

pH was directly measured during water sampling using digital pH meter (Hanna Combo meter, Model- HI 98129).The pH meter was firstly calibrated using pH buffers of 4, 7, and 10. The temperature of instrument was adjusted to correspond the surface water temperature. The electrode was then dipped into the surface water and the reading was recorded. The procedure was repeated three times and the mean value was calculated.

Fig. 1: Sites for raw water sampling a- Ismailia b- Port Said c- Suez.

2.2.3.Turbidity

Water samples were collected in a dark bottle, and were measured directly after returning to laboratory by the turbidity meter (Hanna, Model-HI 88703) the turbidity meter was firstly calibrated as shown in its accompanied manual using a standard of 0.1, 15 and 100 NTU. The turbidity was expressed as nephelometric turbidity unit (NTU).

2.2.4. Conductivity

Conductivity of the water was directly measured using (Hanna Combo meter, Model- HI 98129). The electrode was dipped into water sample and the conductance was recorded. This procedure was repeated three times and the mean value was estimated. The conductance was expressed in µS cm^{-1}.

2.3.Chemical examination of freshwater

2.3.1. Alkalinity

The alkalinity of water is its capacity to neutralize acid. The amount of a strong acid needed to neutralize the alkalinity is called the total alkalinity, which may be expressed in mgL^{-1} equivalent calcium carbonate. The alkalinity of some waters is due only to the bicarbonates of calcium and magnesium. In this study the alkalinity was determined using the titration method of APHA (2005) **(Greenberg et al., 2005).**

Determination of carbonate ions was carried out by titration of 100 mL of water sample with 0.02 M of standard hydrochloric acid after addition of 2 drops of phenolphthalein (ph.ph) until the disappearing of the pink color of (ph.ph). The concentration of bicarbonate was determined by further titration of the same sample after addition of 2 drops of methyl orange until the first perceptible color change towards orange is observed.

Calculation

Phenolphthalein alkalinity as $CaCO_3$

$$P = \frac{100{,}000 \times A \times M}{V}\ mg\ l^{-1}$$

Total alkalinity as $CaCO_3$

$$T = \frac{100{,}000 \times A \times M}{V}\ mg\ l^{-1}$$

$$T = \frac{100{,}000 \times B \times M}{V}\ mg\ l^{-1}$$

Where *A*= volume of standard acid solution (mL) to reach the phenolphthalein end-point of pH 8.3, *B*= volume of standard acid solution (mL) to reach the end-point of methyl orange or mixed indicator, *M* = concentration of acid (mol L^{-1}) *and V* = volume of sample (mL).

2.3.2. Dissolved Oxygen content (DO)

The DO concentration depends on the physical, chemical and biochemical activities in the water body, and its measurement provides a good indication of water quality. Changes in dissolved oxygen concentrations can be an early indication of changing conditions in the water body. Oxygen content of the water was measured using oxygen meter (Jenway – Model 970 DO_2) at the sampling site. The Oxygen meter was firstly calibrated as shown in its accompanied manual, its temperature was adjusted with that of the water. The electrode was dipped in the surface water and the reading was recorded. The procedure was repeated three times and the mean value was calculated and results were expressed as mg L^{-1}.

2.3.3. Chemical oxygen demand (COD)

It provides a measure of the oxygen equivalent of that portion of the organic matter in a water sample that is susceptible to oxidation under the conditions of the test. The method used for determination of COD depended on boiling of known volume of water (20 mL) under reflux with potassium dichromate and silver sulphate catalyst in strong sulphuric acid. Part of the dichromate is reduced by organic matter and the remainder is titrated with ferrous ammonium sulphate.

2.3.4.Total dissolved solids (TDS)

A known volume of well-mixed sample was filtered through a standard fiberglass filter. The filtrate was then evaporated in a pre- weighed dish to constant weight at 180 °C. The difference between the dish weight and the final weight represents the total dissolved solids.

2.3.5. Phosphorus

Phosphorus was measured as orthophosphate by ascorbic acid method (APHA, 4500-P E) [8]. The method based upon the reaction of ammonium molybdate and potassium antimonyl tartarate with orthophosphate in presence of ascorbic acid as reducing agents to form antimonyl-phosphomolybdate complex. This compound yields an intense blue color, which was measured spectrophotometrically at 885 nm using 1 cm cell length.

The reading was corrected for the reagent blank and the phosphate concentration was calculated as follows:

µg at P (PO_4). L^{-1} = E X F

Where E is the corrected extinction for the reagent blank; and F is the factor calculated from the standard orthophosphate solution.

2.3.6. Nitrite

The method was based on the procedure described (APHA, 4500-NO_2-B) **(Greenberg et al., 2005).** The nitrite in water sample was allowed to react with sulphanilamide in an acid solution. The resulting diazo compound was reacted with N-(1-naphthyl)-ethylenediamine and forms a highly colored azo dye, which measured spectrophotometrically at 543nm. The reading was corrected for the reagent blank and the nitriate nitrogen was calculated as follows:

µg at N(NO_2). L^{-1} = E X F

Where E is the corrected extinction for the reagent blank; and F is the factor obtained from the standard nitrite solution.

2.3.7. Nitrate

Nitrate nitrogen was determined by using the method given by (APHA, 4500-NO_3-E) **(Greenberg et al., 2005).** The method based on the reduction of nitrate in water sample to nitrite when a sample was run through a column containing cadmium filing coated with metallic copper. The nitrate was determined by diazotizing with sulphanilamide and coupling with N- (1-naphthyl)-ethylenediamine. A highly colored azo dye was formed and measured spectrophotometrically at 543nm. The nitrate initially present in the sample must be subtracted from the total nitrate, and the reading was corrected for the reagent blank. The nitrate nitrogen was calculated as follows:

µg at N(NO_3). L^{-1} = E X F -0.95C

Where E is the corrected extinction for the reagent blank; and F is the factor obtained from the standard nitrate solution; and C is the concentration of nitrite in the sample in µg at N(NO_2) L^{-1}.

2.3.8. Ammonium

Nitrogen was determined colorimetrically using the method given (APHA, 4500-NH_3-F). Water sample was treated, in an alkaline citrate medium, with sodium hypochlorite and phenol in presence of sodium nitroprusside as a catalyst. A blue indophenols color formed with ammonia and was then measured spectrophotometrically at 640nm. The reading was corrected for the reagent blank and the ammonium nitrogen was calculated as follows:

µg at N(NH_4). L^{-1} = E X F

Where E is the corrected extinction for the reagent blank; and F is the factor obtained from the standard ammonium solution.

3. Results and Discussion

The range and average of the measured physicochemical parameters for freshwater or pre-treated samples and for treated or tap water samples collected from the selected sites in the three governorates were presented in table 1 and 2; respectively. The monitoring of these parameters was carried out over the research period from May 2008 to February 2011.

3.1. Physical Parameters

3.1.1. Air and water temperature

There is a closed relation between the atmospheric temperature and water temperature. Air temperature is one of the most important ecological factors which control the physiological behavior of the aquatic system and distribution of the microorganisms **(Arain et al., 2009).**

Variation in water temperature showed seasonal trend, with higher degrees in summer and lower ones in winter. Moreover, the variations at different studied sites were closely related to each other. A little difference in temperature could be seen among the selected sites in the three governorates (Ismailia, Port Said, and Suez). In Ismailia the air temperature had a range of 18- 37 °C in with an average of 27.8 °C, the surface water temperature had a range of 15.5-29 °C, with an average of 22.6 °C, While in Port Said the air temperature had a range of 17- 32 °C with an average of 25.1 °C, the surface water temperature had a range of 14 -28 °C, with an average of 21.7 °C. Finally in Suez the air temperature had a range of 17- 35 °C with an average of 26.6 °C, the surface water temperature had a range of 16 -28.5 °C, with an average of 21.9 °C The difference between air and water temperatures was thus, 2 °C for winter and 4-6 °C for summer. The monthly values of both air and water temperature (°C) of fresh water, were shown in Fig. 2.

3.1.2. Concentration of hydrogen ion (pH)

pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. The variation in the pH values occurs due to change in the values of CO_2, carbonate and bicarbonate in the water **(Joshi et al., 2009).** The lower values of pH may cause tuberculation and corrosion while the higher values may produce incrustation, sediment, deposition and difficulties in chlorination for disinfections of water **(Priyanka et al., 2009).** In the present study the pH values for fresh water samples collected from Ismailia ranged from 7.5 to 8.2 with an average of 7.78, while for treated water samples ranged from 7.1 to 7.3 with an average of 7.11. Fresh water samples collected from Port Said showed pH values ranged from 7.5 to 8.3 with an average of 7.81, while for treated water samples ranged from 7.1 to 7.5 with an average of 7.23. Fresh water samples collected from Suez showed pH values ranged from 7.3 to 8.2 with an average of 7.8, while for treated water samples ranged from 7.1 to 7.3 with an average of 7.13. The mean pH values recorded for all samples from both fresh and treated water were within the **EMOH, EPA and WHO** pH tolerance limit of between 6.5 – 8.5 for surface water and drinking water. The pH values of fresh water samples were shown in Fig. 3.

3.1.3. Turbidity

The mean of turbidity values of fresh water samples were 17.56, 23.70 and 22.26 NTU for Ismailia, Port Said and Suez; respectively. For treated water samples the mean were 0.20, 0.25, and 0.20 NTU for Ismailia, Port Said and Suez; respectively. The turbidity measurements for all samples were within the **EMOH and WHO** standard levels, which should not be more than 100 NTU for fresh water and should not be more than 1 NTU for drinking water. The turbidity values (NTU) of fresh water samples were shown in Fig. 4.

3.1.4.Conductivity (EC)

Electrical conductivity is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts **(Rhoades et al., 1999).** EC mean values for fresh water samples were 474.45, 440.27 and 418.59 for Port Said, Ismailia and Suez; respectively. The mean conductivity values for all the sampling point were within the common values for surface water. The EC values of fresh water samples were shown in Fig. 5.

3.1.5. TDS

It was reported that alkaline ponds were richer in solids than acidic ones. The quantity of TDS was proportional to the degree of pollution **(Nasrulla et al., 2006).** The mean value of TDS in the collected fresh water samples were 310.32, 286.82 and 272.27 mg L^{-1} for Port Said, Ismailia and Suez; respectively. The mean value of TDS in the collected treated water samples were 289, 264 and 273 mg L^{-1} for Port Said, Ismailia and Suez; respectively. The mean TDS values for all the samples of both fresh and treated

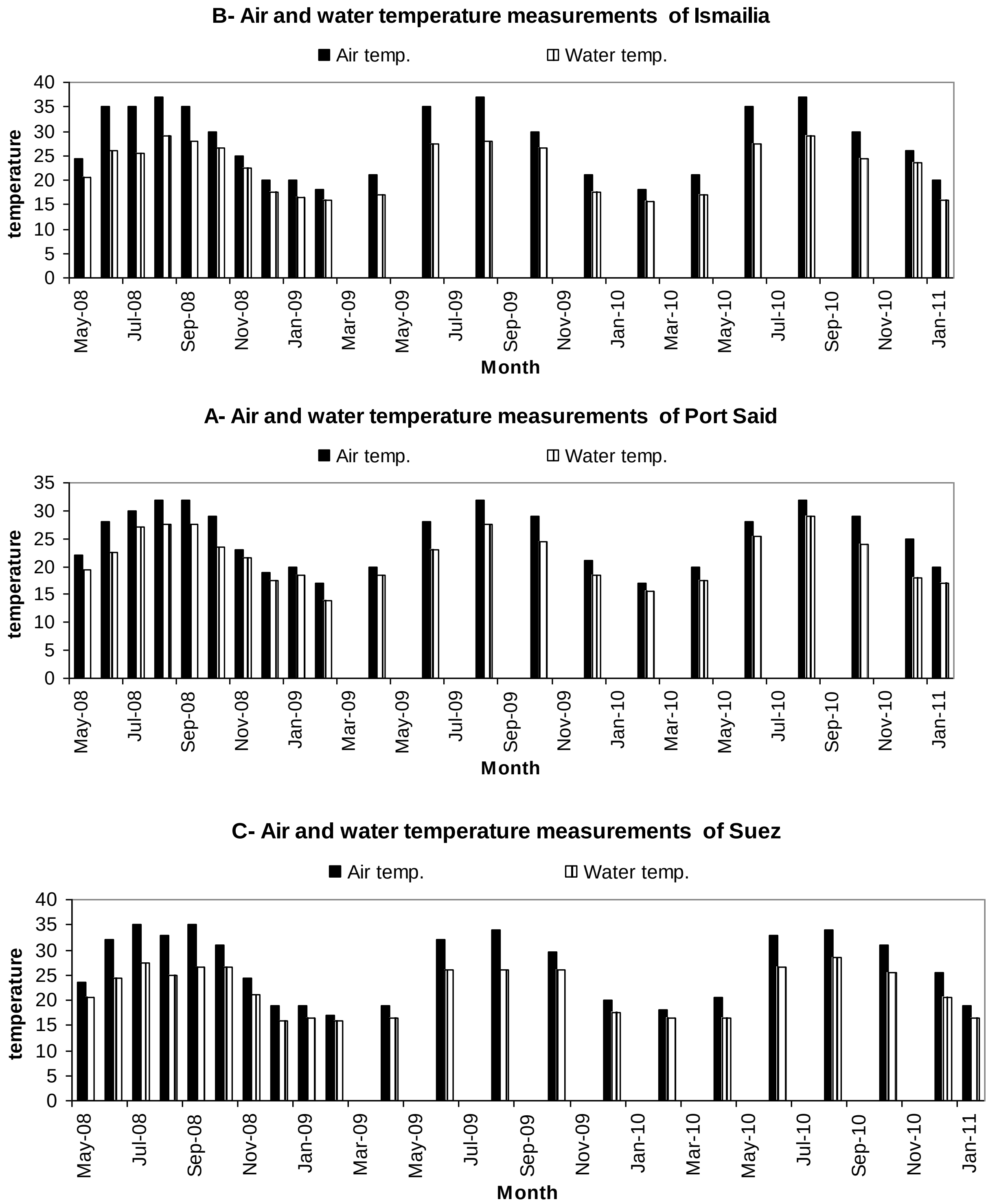

Fig. 2: Air and water temperature measurements A- Port Said B- Ismailia C- Suez

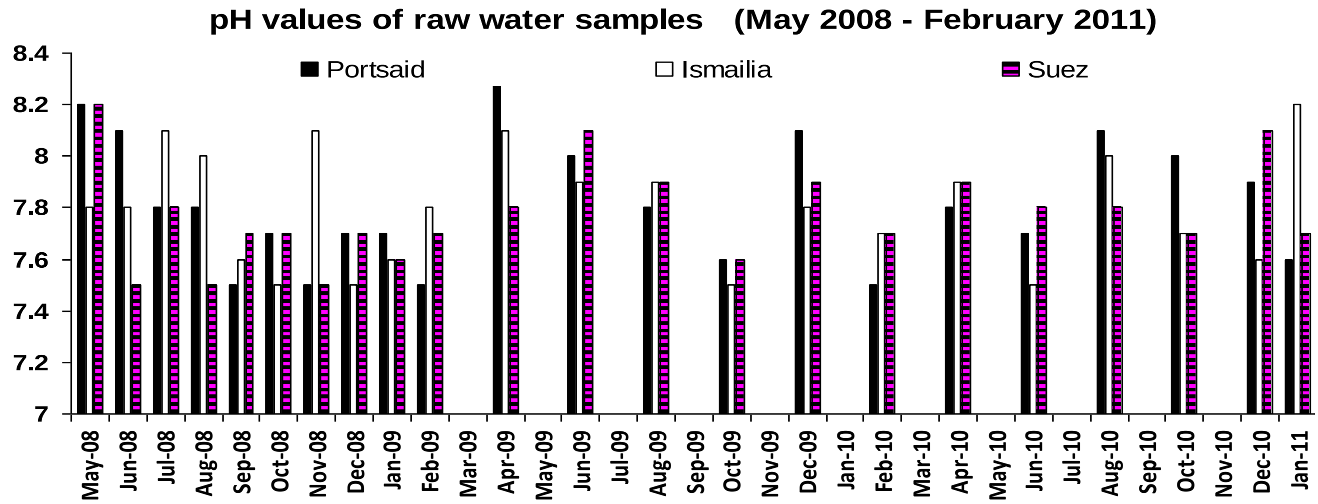

Fig. 3: The pH values of fresh water samples in Ismailia, Port Said and Suez.

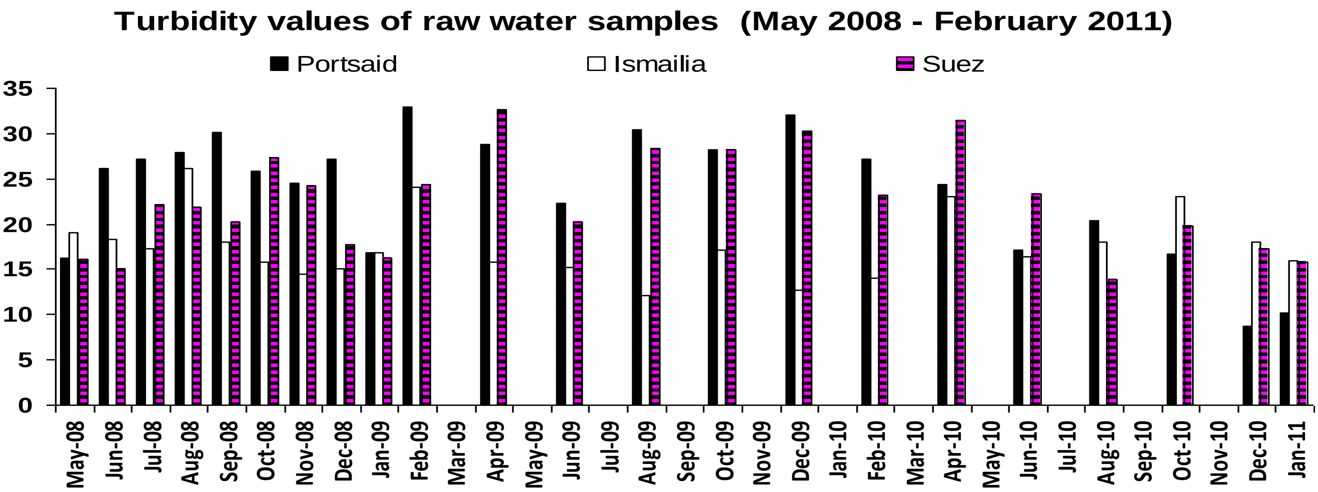

Fig. 4: The turbidity values of fresh water samples in Ismailia, Port Said and Suez.

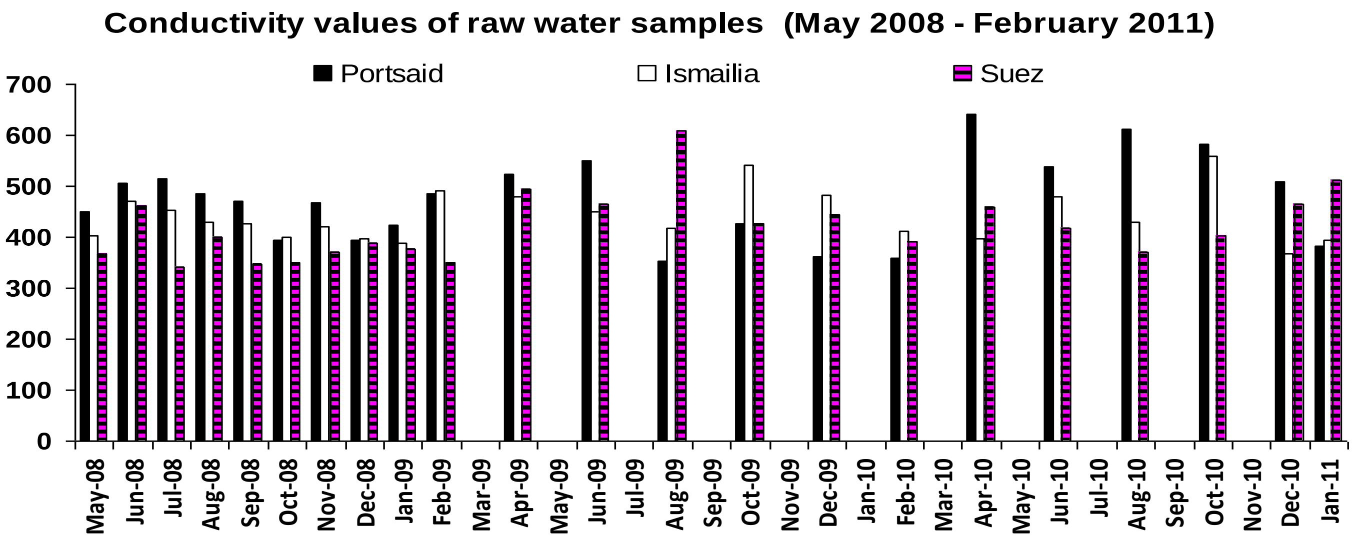

Fig. 5: The electric conductivity values of fresh water samples in Ismailia, Port Said and Suez.

water were within the **EMOH** guideline values of 500 and 1000 mg L^{-1} for fresh and treated water; respectively. The TDS values of fresh water samples were shown in Fig.6.

3.2.Chemical parameters

3.2.1. Alkalinity

Alkalinity of water is measure of its capacity to neutralize acids. This is due to the primarily salts of weak acids or strong bases. Bicarbonates, represent the major form of alkalinity. Bicarbonates are formed in considerable amount from the action of carbon dioxide upon basic materials in soil and other salts of weak acids **(Ajit and Padmakar, 2012).**

Throughout the study period, the mean total alkalinity values of the collected fresh water samples were 190.68, 202.59 and 196.55 mg L^{-1} for Port Said, Ismailia and Suez; respectively. The mean total alkalinity values in the collected treated water samples were 138.0, 115.4 and 121.1 mg L^{-1} for Port Said, Ismailia and Suez; respectively. The mean total alkalinity values for all the samples of both fresh and treated water were within the **EMOH** guideline values of 500 mg L^{-1} for both fresh and treated water. The total alkalinity values of fresh water samples were shown in Fig. 7.

3.2.2. Dissolved Oxygen content (DO)

Dissolved oxygen is one of the most important parameter in assessing water quality and understanding the physical and biological process prevailing in the water. As shown in Table 1. The mean DO values of the collected fresh water samples were 6.9, 6.3 and 6.5 mg L^{-1} for Port Said, Ismailia and Suez; respectively. The DO is a measure of the degree of pollution by organic matter, the destruction of organic substances as well as the self purification capacity of the water body. The standard for sustaining aquatic life is stipulated at 5 mg L^{-1} a concentration below this value adversely affects aquatic biological life, while concentration below 2 mgL^{-1} may lead to death for most fishes **(Deborah, 1996).** The DO level at Port Said, Ismailia and Suez were above the **EMOH** guideline value of not less than 5 mgL^{-1}. The DO values of fresh water samples were shown in Fig. 8**3.2.3. Chemical oxygen demand (COD)**

Chemical Oxygen Demand (COD) is the measure of amount of oxygen required by both potassium dichromate and concentrated sulfuric acid to breakdown both organic and inorganic matters. COD concentration of the fresh water was measured. The mean COD values of the collected fresh water samples were 12.4, 11.1 and 12.3 for Port Said, Ismailia and Suez; respectively (Table 1). The concentrations of COD in all fresh water samples from all sampling points were higher than the WHO and **EMOH** guideline value for fresh water which should not exceed 10 mg L^{-1}. High COD concentration observed might be due to the use of chemicals, which are organic or inorganic that are oxygen demand in nature, dumping of animal waste and the presence of a number of sewage pipes that empty into the canal. The COD values of fresh water samples were shown in Fig. 9.

3.2.4. Phosphorus, nitrite , nitrate and ammonia

I) Fresh water samples

The mean concentrations of phosphorus as orthophosphate were 26.64, 21.19 and 25.35 µg L^{-1} for Port Said, Ismailia and Suez; respectively. The mean concentrations of nitrite were 0.009, 0.011 and 0.007 mg L^{-1} for Port Said, Ismailia and Suez; respectively. The mean concentrations of nitrate were 0.022, 0.018 and 0.016 mg L^{-1} for Port Said, Ismailia and Suez; respectively. The mean concentrations of ammonia were 9.02, 7.82 and 9.83 µg L^{-1} for Port Said, Ismailia and Suez; respectively. The measured concentrations did not exceed the **EMOH** maximum contaminant level 45, 3 and 0.5 mg L^{-1} for nitrate, nitrite and ammonia; respectively. 0.5 mg $L^{-1}$for the fresh water for phosphate and ammonia; respectively (Table 1).

II) Treated water samples

Nitrites and nitrates were not detected in all treated water samples collected from the three governorates. Ammonia was detected in few samples from Port Said and their mean concentration was 0.004 mg L^{-1} but did not exceed the **EMOH** maximum contaminant level, which is 0.5 mg L^{-1} (Table 2).

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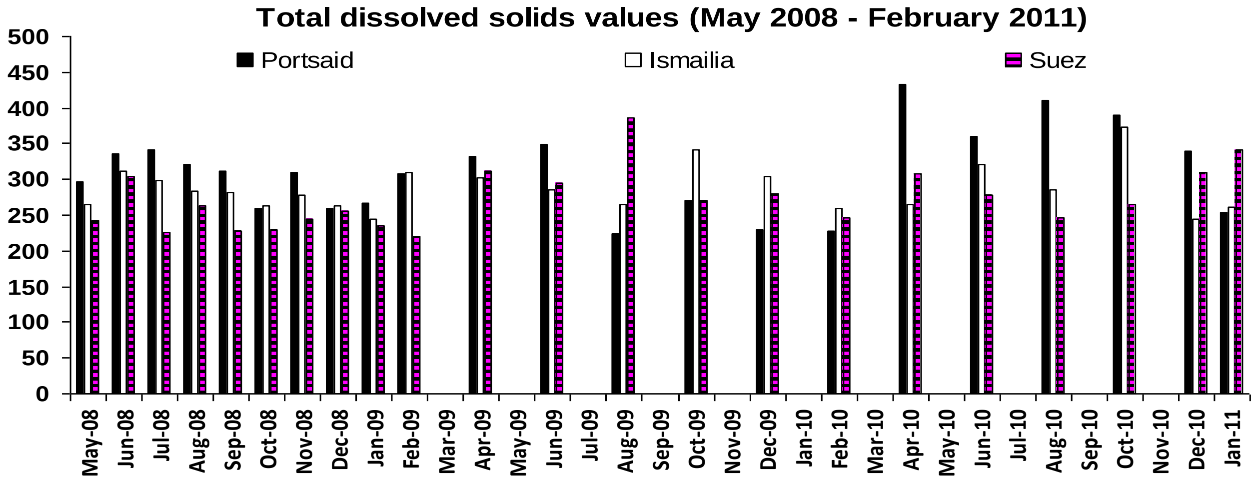

Fig. 6: The total dissolved (TDS) solids values of fresh water samples in Ismailia, Port Said and Suez.

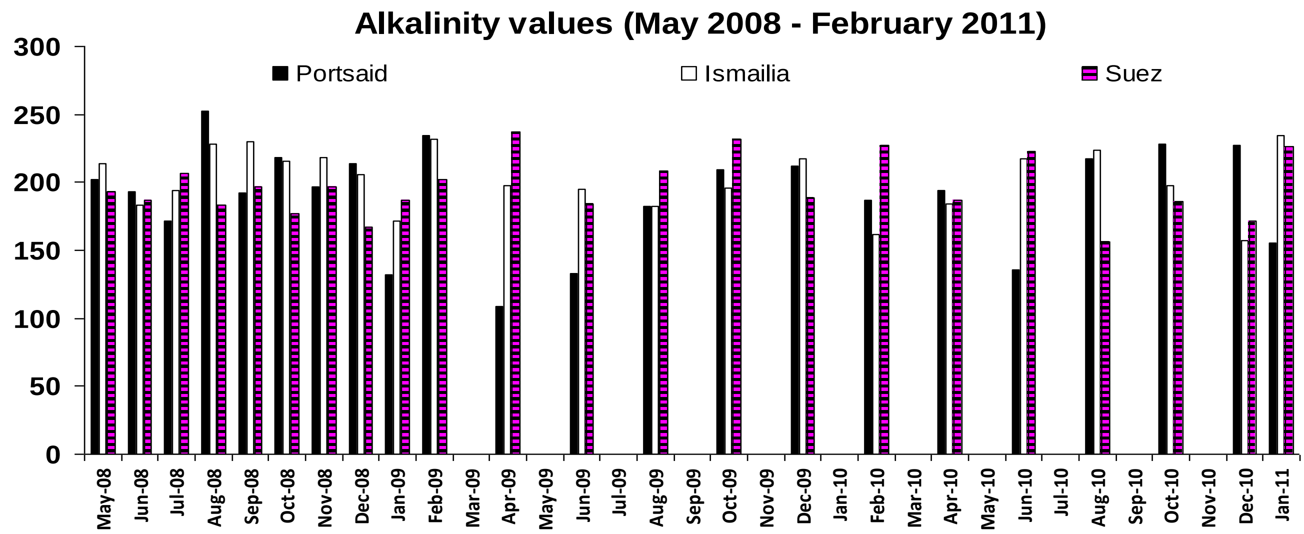

Fig. 7: Alkalinity values of fresh water samples in Ismailia, Port Said and Suez.

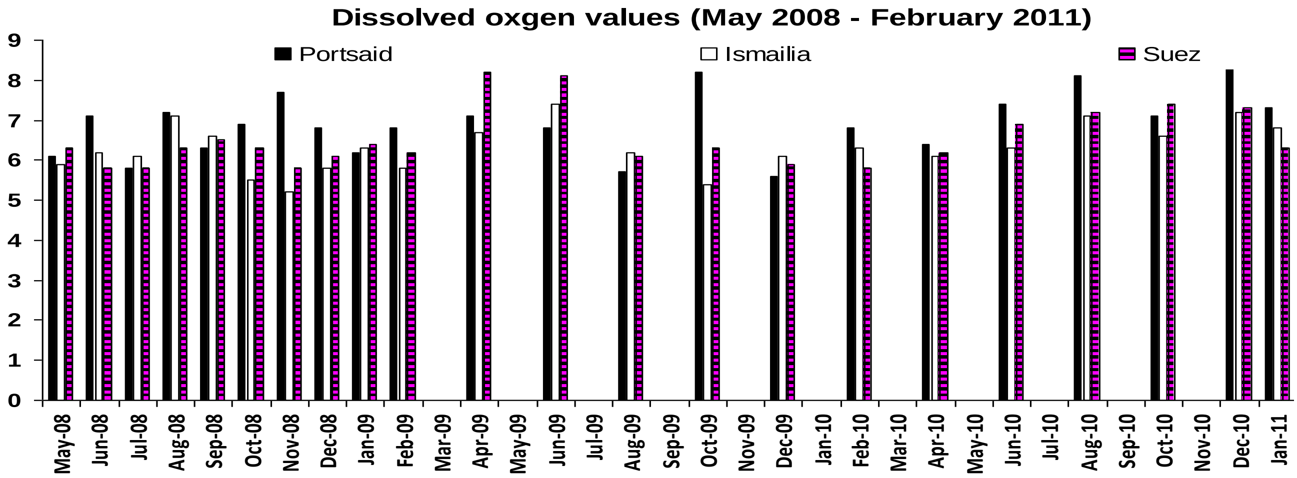

Fig. 8: Dissolved oxygen values of fresh water samples in Ismailia, Port Said and Suez.

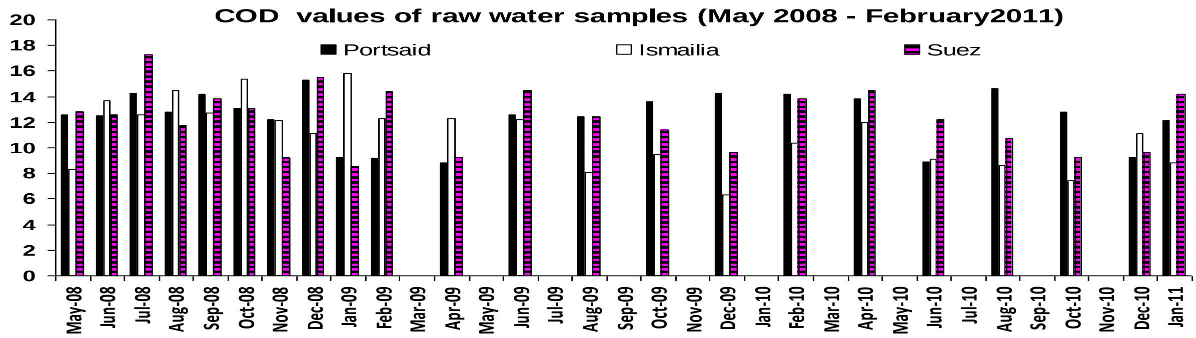

Fig. 9: Chemical oxygen demand values of fresh water samples in Ismailia, Port Said and Suez.

Table 1: Physico-chemical parameters of freshwater samples collected from Ismailia, Port Said and Suez during the period from May 2008 to February 2011.

Parameter	Ismailia		Port Said		Suez		Standard limits EMOH [8]
	range	average	range	average	range	average	
Air temp. °C	18-37	27.8	17 - 32	25.1	17-35	26.6	No Index
Water temp. °C	15.5 - 29	22.6	14- 28	21.7	16 – 28.5	21.9	No Index
pH	7.5-8.2	7.78	7.5 – 8.3	7.81	7.3-8.2	7.8	6.5 – 8.5
Turbidity (NTU)	12.1 - 26.2	17.56	8.7 - 33	23.7	13.9- 32.6	22.26	< 100 NTU
EC./µS cm^{-1}	369 - 559	440.27	354 -641	474.45	342 - 608	418.59	No Index
Alkalinity/mg L^{-1}	157 - 234	202.59	132 - 252	190.68	156 - 237	196.55	<500 mg L^{-1}
DO/mg L^{-1}	6.6 – 9.8	6.3	5.8 – 9.3	6.9	5.8 – 9.3	6.5	> 5 mg L^{-1}
COD/mg L^{-1}	8.8 – 14.4	11.1	7.5 – 14.6	12.4	8.5 – 16.7	12.3	<10 mg L^{-1}
TDS/mg L^{-1}	220 - 374	286.82	233 - 412	310.32	230 - 386	272.27	< 500 mg L^{-1}
Phosphorous/µg L^{-1}	11.4 – 33.2	21.19	12.1 -38.8	26.64	16.8 – 35.1	25.35	No Index
Nitrate / mg L^{-1}	ND – 0.031	0.018	ND – 0.042	0.022	ND – 0.028	0.016	< 45 mg L^{-1}
Nitrite / mg L^{-1}	ND – 0.018	0.011	ND – 0.013	0.009	ND – 0.010	0.007	< 3 mg L^{-1}
Ammonia / µg L^{-1}	4.9 – 10.2	7.82	3.7 -16.3	9.02	5.5 – 14.3	9.83	< 0.5 mg L^{-1}

ND = Not detected.

EMOH= Egyptian ministry of health.

. Table 2: Physico-chemical parameters of treated water (tap water) samples collected from Ismailia, Port Said and Suez during the period from May 2008 to February 2011.

Parameter	Ismailia		Port Said		Suez		WHO MCL [6]	EMOH MCL [8]
	range	average	range	average	range	average		
Air temp. ^0C	--	--	--	--	--	--	No Index	No Index
Water temp. ^0C	--	--	--	--	--	--	No Index	No Index
pH	7.10 -7.30	7.11	7.10 – 7.50	7.23	7.10 - 7.30	7.13	6.5 – 8.5	6.5 – 8.5
Turbidity (NTU)	0.20 – 0.30	0.20	0.20 – 0.30	0.25	0.20 – 0.30	0.20	< 1 NTU	< 1 NTU
EC./µScm^{-1}	--	--	--	--	--	--	No Index	No Index
Alkalinity/mgL^{-1}	109 - 154	115.4	110 - 160	138	96 .2 – 149	121.1	No Index	<500 mg L^{-1}
DO/mgL^{-1}	--	--	--	--	--	--	No Index	No Index
COD/mgL^{-1}	--	--	--	--	--	--	No Index	No Index
TDS/mgL^{-1}	238 - 381	264	211 - 392	289	218 - 363	273	< 600 mgL^{-1}	< **1000** mg L^{-1}
Phosphorus/µg L^{-1}	--	--	--	--	--	--	No Index	No Index
Nitrate / µg L^{-1}	ND		ND		ND		50 mg L^{-1}	< 45 mg L^{-1}
Nitrite / µg L^{-1}	ND		ND		ND		3 mg L^{-1}	< 2 mg L^{-1}
Ammonia / mgL^{-1}	ND		ND – 0.02	0.004	ND		No Index	< 0.5 mgL^{-1}

ND = Not detected
WHO MCL= World health organization maximum contaminant level.
EMOH MCL= Egyptian inistry of health maximum contaminant level.

4.Conclusion

All the measured physicochemical parameters of fresh water samples were within the acceptable limits except chemical oxygen demand (COD) is above the acceptable limits this may be due to dumping of animal waste and the presence of a number of sewage pipes that empty into the canal, but all measured physicochemical parameters of treated (tap) water samples are within the acceptable limits.

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