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Physical-chemical and Bacteriological Evaluation of River Nile Water and Drinking Water in Benha City, Egypt

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WATER quality assessment of drinking water has been studied in Benha city, Qalubia Governorate, Egypt between April 2015 to March 2016 to evaluate the quality of different types of water according to physicochemical, chemical and bacteriological aspects. Twenty four samples were collected during the four seasons from different places in Benha City. Two kinds were analyzed; Benha filtered water and raw water of River Nile. The results indicated that the average values of physicochemical, heavy metals, trihalomethanes and bacteriological parameters in Benha filtered water treatment were within Egyptian standard (2007) and the World Health Organization (WHO) of water quality with comparison to raw water. The dominant bacterial isolates in the raw water samples were *Escherichia coli* and *Enterobacter aerogenes*; while the filtered water samples were 100% free from pathogenic bacteria and coliforms.

Keywords: Physicochemical parameters, Microbial parameters, Correlations coefficient, River Nile, Heavy metals.

Introduction

The main water source is the River Nile in Benha city.The Department of Environment (D.O.E.) monitors the river basins for major contaminant sources (Chan, 2004), while the quality of the raw water reservoir is monitored by state water monitoring and controlling authorities (Hasbiyana, 2008). The main source of filtered water for Benha city is New Benha filtered water treatment plant of Atripe area with design capacity (68000 m^3 / day) which produces (56,000 m^3 / day) to pump water into the water networks.

Man consumes water to survive. Clean drinking water is always needed for human health. The mortality of people aworld due to water associated diseases exceeds 5 million people per year (UN-Water, 2013). Therefore, water quality control is very important in many parts of the world (WHO, 2011). Determination of physical and chemical (inorganic and organic) parameters is very important to evaluate water quality (Dissmeyer, 2000). Contaminants in the water can affect the water quality and consequently the human health. These contaminants are categorized as (microorganisms, inorganics and organics) (Nollet, 2000). Both geological conditions, industrial and agricultural activities cause water to be non potable.

Perhaps, as a result of human needs for potable water, bottled water industry appeared to take a place (Gleick & Cooley, 2009). Also, the ease of availability, convenience to carry, better taste, reasonable cost and freedom from impurities made bottled water consumed safely in most of developing and developed countries (Nickson et al., 2005). The quality of drinking water is a powerful environmental determinant of health.

Water is unsafe for human consumption when it contains pathogenic or disease-causing microorganisms such as bacteria and hazardous chemicals. Water is said to be polluted when heavy metals and pathogenic bacteria present in it (Shalaby et al., 2000). Microbial evaluation of drinking water is considered as indicator of

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potential water born disease (Soliman, 2000). Heavy metals are known to elicit a number of immuno-modulatory effects ultimately to microbial agent and the appearance of diseases and the immune phenomena. Coliform bacteria are the bacteria most commonly associated with water quality. *Escherichia coli* (*E.coli*) has been shown to be more related to the sanitary risk than other coliforms (Fewtrell & Bartram, 2001).

The main objective of the present work was to evaluate the quality of water according to physicochemical, chemical and bacteriological aspects in Benha City, to isolate and identify the predominant isolates of bacteria to assess the bactericidal effect of chlorine on bacteria and to monitor total trihalomethanes (THMs) in all kinds of water from different sources (raw water and filtered water) in Benha City.

Materials and Methods

Collection of samples

The present field study was carried out to detect some physicochemical, chemical (heavy metals & trihalomethanes) and bacteriological parameters in the raw water and also in produced water from Benha Drinking Water Treatment Plant (BDWTP) in Benha City - Qalubia Governorate. All water samples were collected according to American Public Health ssociation(APHA, 2005) and collected over the period of one year from April 2015 to March 2016

Physicochemical characteristics

Different physical properties were measured by using standard technical methodologies. List of measured parameters includes, (pH), turbidity, electrical conductivity (EC), total dissolved solids, (TDS total alkalinity, chloride (Cl^-), residual chlorine, total hardness, calcium hardness, magnesium hardness, calcium, magnesium and sulphate (SO_4^{2-}) were determined according to (APHA, 2005). In addition, chemical analysis Includes determinations of Trihalomethanes and heavy metals as Cd, Cr, Fe, Mn, Ni, Pb, Al (µg/l) .

Determination of heavy metals

The heavy metals' concentrations were measured according to European Protection Agency (U.S. EPA, 2007), method 3015A. Sample (45mL) was taken with 5 ml of conc. nitric acid ultra pure in the microwave which heated samples to 170°C for 10 min and then heating was continued at 170°C for another 10 min. The microwave was used for digestion of the samples with conc. nitric acid, before analysis. The heavy metals' concentrations were determined using Inductively Coupled Plasma (ICP), model Perkin Elmer Optima 8300DV optical system (Photo, 1).

Determination of chlorination disinfection byproducts in drinking water

Trihalomethanes analyses were determined according to EPA (2010). A 25 mL sample was extracted with 5 mL of Hexane. The mixture was shaken thoroughly for 180 turn /min for 20 min and the layers were let to separate for 10 min. The organic (1 mL) was then injected in the vial using Pasteur pipette. One µL of the extract was then injected to a gas chromatography GC (Photo, 2) equipped with a fused silica capillary column and electron capture detector (ECD) for separation and analysis. The extract was separated into the analyze peaks and the samples at the same time. The components recognized by their retention time, from injected standard solution. The Gas chromatography used was GC Varian CP-3800 with capillary column DB5 (30m, 0.25mm & 0.25 ID) equipped with electron capture detector ECD (Ni) 63, split/split less injector and auto sampler to inject the samples automatically

Photo,1. Inductively coupled plasma optical emission spectroscopy (ICP)

Bacteriological methods

Water samples were analyzed for the determination of classical bacterial indicators of pollution, water samples were separately collected in clean, dry autoclavable polypropylene containers. Samples were transferred immediately to the laboratory in the ice box and analyzed. All the bacteriological tests and the consequently used culture media were performed according to recommended methods in the standard methods for examination of drinking water and raw water (APHA, 2005).

Photo, 2 Gas Chromatography (GC)

Enumeration of total viable bacterial count (TVBC) using pour plate method

The total viable bacterial count TVBC (CFU/ml) was carried out using (Reasoner´s 2A agar) (R2A) . Plates were incubated at 22°C for 7 days and also at 35±0.5°C for 48 h. After the incubation period, all plates were counted by the use of colony counter.

Enumeration of total coliform

Total coliform (TC) were determined using membrane filter (MF) technique. M-Endo LES medium was used as a presumptive test for total coliform. The inoculated inverted plates were incubated at 35 ± 0.5°C for 22 to 24 h after which presence of typical coliform colony or atypical coliform colonies indicate positive presumptive test. Lauryl tryptose broth and brilliant green broth (BGB) were used as a verification test for total coliform. Both lauryl tryptose broth and brilliant green lactose bile broth (BGB) were inoculated with the selected colonies and incubated at 35.0 ± 0.5°C for 24-48 h.The production of acid and gas was recorded as a positive verification test for TC.

Enumeration of fecal coliform

Fecal coliform (FC) were determined using membrane filter (MF) technique. MFC medium was used as a presumptive test for fecal coliform. The inoculated inverted plates were incubated at 44.5± 0.2°C for 22 to 24 h after which presence of coliform colony indicate positive presumptive test. Lauryl tryptose broth and EC broth were used as a verification test for fecal coliform. Both lauryl tryptose broth and EC broth were inoculated with the selected colonies with lauryl tryptose broth incubated at 35.0 ± 0.5°C for 24-48 h and EC broth incubated at 44.5 ±0.2°C for 24 h. The production of acid and gas was recorded as a positive verification test for FC.

Enumeration of fecal streptococci

Fecal streptococci (FS) were determined using membrane filter (MF) technique. M-Enterococcus agar medium was used as a presumptive test for fecal streptococci. The inoculated inverted plates were incubated at 35 ± 0.5°C for 48 h after which presence of coliform colony indicate positive presumptive test. Brain-heart infusion agar, bile esculin agar, 6.5% NaCl broth, and at 45°C in brain-heart infusion broth were used as a verification test for fecal coliform. Selected typical colonies from a membrane were picked and streaked for isolation onto the surface of a brain-heart infusion agar, incubation at 35 ± 0.5°C for 24 to 48 h.

Preparation of pure cultures

Pure cultures of each morphological distinct bacterial colony which was isolated on Tryptone Soy Agar (T.S.A. agar) plates were prepared. Each colony was inoculated separately onto T.S.A. agar plates. The agar plates were incubated for 24 h at 35°C in order to obtain single bacterial colonies and preservation in nutrient agar slants for long time to perform the research on this isolate bacteria.

Identification of bacterial species

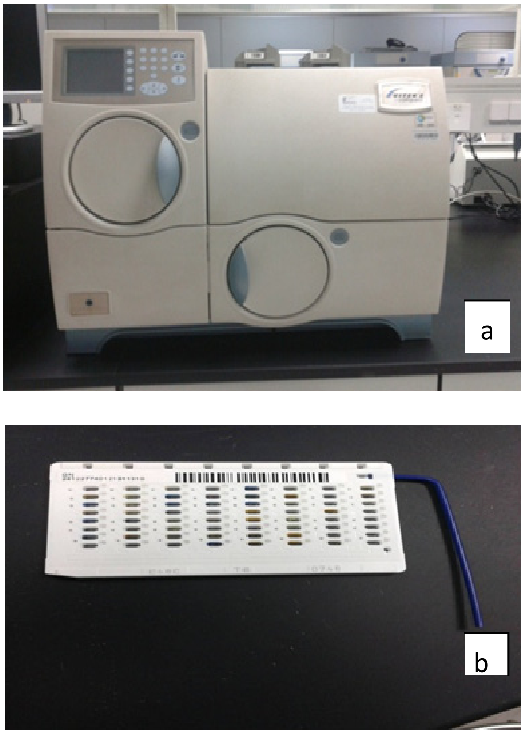
Identification of bacterial species was carried out using the VITEK® 2 identification card (Photo, 3 a, b) (Chen, et al., 2006). The card is based on established biochemical methods and newly developed substrates. There are 36 biochemical tests measuring carbon source utilization and enzymatic activities.

The organism to be tested was subcultured to appropriate agar medium and incubated accordingly. 3.0 mL of sterile saline (aqueous 0.45% NaCl, pH 4.5) was transferred into a clear plastic (polystyrene) test tube (12 mm x 75 mm). A sterile stick or swab was used to transfer a sufficient number of morphologically similar colonies to the saline tube prepared. Thus, a homogenous organism suspension was prepared. Identification cards were inoculated with microorganism suspensions using an integrated vacuum apparatus and card was entered into VITEK 2 compact systems in Reference Laboratory for Drinking Water in Shubra El Kheima, Qalubia Governorate. Age of suspension must be within 30 min before inoculating card.

Results and Discussion

The quality of water is now the concern of experts in the countries of the world. Water quality depends on the location of water source and the environmental status in the selected area. Therefore, the quality and the nature of water may be determined by physical and chemical analyses within the permissible limits of Egyptian Standard

(2007). The physicochemical parameters are considered as the most important principles in identification of the nature, quality and type of water for any aquatic ecosystem (Abdo, 2005)



Photo, 3. (a) VITEK 2 compact systems and (b) VITEK® 2 identification card

Physico-chemical parameters of both raw and produced water

Comparison between different physicochemical parameters of raw and produced water was illustrated in Table 1.

In the month of January 2016, the highest pH values of the raw water and the produced water were recorded (8.68 and 7.85), respectively and the lowest pH value (7.09) in the raw water was in September 2015; while the lowest pH value (6.9) in the produced water was in May 2015. These values are always higher in the raw water due to the presence of normally expected carbonates or bicarbonates as reported by Friendl et al. (2004). The increase in pH in the rivers could be related to photosynthesis and growth of aquatic plants (Yousry et al., 2009)

In the raw water, the highest turbidity value (8.37 N.T.U.) was shown in March 2016 with high numbers of microorganisms; while that of the produced water (0.95 N.T.U.) was in October 2015.The lowest turbidity value of the raw water (2.4 N.T.U.) was in February 2016 by uptake of suspended matter by phytoplankton's as well as penetrating the water surface by high intensity solar radiation, that agreed with Abdo (2002); while in September 2015, the lowest turbidity value in the produced water was shown (0.1N.T.U.).

In October 2015, the highest total dissolved solids values of the raw water and the produced filtered water were recorded (308.88 mg/L and 310.2 mg/L) respectively. While, in June 2015, the lowest total dissolved solids values were recorded (218 mg/L and 234 mg/L), respectively. High levels of TDS cause corrosion and mineral deposits in pipes (US EPA, 1992).

The highest total hardness values of the raw water and the produced water were recorded (180 mg/L and 160 mg/L), respectively, the highest value which attributed to dissolution of compounds containing calcium in the presence of high CO_2 content (Elewa, 1993). The lowest total hardness value of the raw water (88 mg/L) was in July 2015; while the produced water (90 mg/L) was in June 2015 .The lowest total hardness value that may refer to the loss of calcium by precipitation as $CaCo_3$, that accompanied by a low value of dissolved oxygen (Ali et al., 1992). Generally the increase in hardness is due to the nature of the soil rich with calcium carbonate or bicarbonate that dissolve in the raw water and increase the hardness. The calcium in water was resulting from dissolution of it when water comes in contact with limestone, gypsum or dolomite (APHA, 1998).

In March 2016, the highest magnesium hardness values of the raw water and the produced water were recorded (112 mg/L and 80 mg/L) respectively. In May 2015, in the raw water, the lowest value of magnesium hardness concentration was recorded (25.2 mg/L); while the lowest value in the produced water (20 mg/L) was in February 2016. The results in the raw water agreed with Daboor (2006). The increase of Mg hardness may be due to the dissolution of compounds containing Mg during the drought period, but the decrease may due to its uptake by aquatic microorganisms and phytoplanktons (Nour El Din, 1985).

In the raw water, the lowest total chlorides value was 19 mg/L in June 2015; while the lowest total chlorides value in the produced water was 22 mg/L in September 2015.In January 2016, the highest chlorides values in the raw water and the produced water were recorded (43.05 mg/L and 53.55 mg/L), respectively. In the raw water Increase of chloride's concentration in the water may be due to the presence of high concentration of sodium chloride in it APHA (1998).

TABLE1. Physico-chemical parameters of both raw water samples and produced water from Benha Filtered Water Treatment Plant.

Parameter & month	R.CL.		Turbidity (NTU)		pH		Cond. (µs/cm)		T.D.S. (mg/L)		Alkalinity (mg/L)		Chlorides (mg/L		T.H.(mg/L)		Ca.H. (mg/L)		Mg.H. (mg/L)		Ca (mg/L)		Mg (mg/L)		Sulfate (mg/L)	
	R.W	P.W	R.W	P.W	R.W	P.W	R.W	P.W	R.W	P.W	R.W	P.W	R.W	P.W	R.W	P.W	R.W	P.W	R.W	P.W	R.W	P.W	R.W	P.W	R.W	P.W
Jan.	N.D.	1.28	5.58	0.79	8.68	7.85	390	399	257.4	263.34	156	150.2	43.05	53.55	120	120	70	74	50	46	28	29.6	12	11.04	46.53	57.29
Feb.	N.D.	1.85	2.4	0.4	8	7.4	404	413	266.64	272.58	170	150	40	47	156	100	80	80	76	20	32	32	18.24	4.8	48.26	47.57
March	N.D.	1.83	8.37	0.27	7.9	7.19	376	403	248	266	159.9	136.5	27.3	33.6	180	160	68	80	112	80	27.5	23	26.8	19.2	35.4	49.6
April	N.D.	1.19	5	0.4	8	7.5	407	424	269	280	168	148.2	32	36.75	106	120	62	60	44	60	24.8	24	10.56	14.4	34.38	48.26
May	N.D.	1.81	7.4	0.3	7.5	6.9	379	367	250	242	140	132	22.05	27.3	96.9	93.6	71.4	60.45	25.2	33.15	28.56	24.18	6.05	7.96	11.42	30.45
June	N.D.	1.56	7.64	0.65	7.63	7.13	330	355	218	234	136.5	117	19	28	90	90	60	58	30	32	24	23.2	7.2	7.68	18.54	13.68
July	N.D.	2.2	7.69	0.39	7.7	7.07	359	421	236.94	277.86	144.3	136.5	21	28.35	88	92	60	60	28	32	24	24	6.72	7.68	27.5	42.7
Aug.	N.D.	1.64	8.31	0.25	7.63	7.12	363	373	239.58	246.18	148.2	136.5	22.05	29.4	110	96	60	58	50	38	24	23.2	12	9.12	31.46	39.24
Sept.	N.D.	2.05	7.07	0.1	7.09	7.2	417	427	275.22	281.82	171.6	160	25.2	22	110	120	66	68	44	52	26.4	27.2	10.56	12.48	29.55	41.32
Oct.	N.D.	1.5	4.43	0.95	7.87	7.28	468	470	308.88	310.2	160	138.5	33.6	36.75	112	108	74	66	38	42	29.6	26.4	9.12	10.08	40.62	47.57
Nov.	N.D.	1.12	5.86	0.71	7.89	7.31	421	424	277.86	279.84	156	146.3	31.5	39.9	126	120	64	74	62	46	25.6	29.6	14.88	11.04	40	48.96
Dec.	N.D.	2.5	4.45	0.66	7.99	7.43	417	435	257.22	287.1	163.8	156	40.95	51.45	138	136	70	78	68	58	28	31.2	16.32	13.92	48.26	61.46
Min.	N.D.	1.12	2.4	0.1	7.09	6.9	330	355	218	234	136.5	117	19	22	88	90	60	58	25.2	20	24	23	6.05	4.8	11.42	13.68
Max.	N.D.	2.5	8.37	0.95	8.68	7.85	468	470	308.88	310.2	171.6	160	43.05	53.55	180	160	80	80	112	80	32	32	26.8	19.2	48.26	61.46
Average	N.D.	1.711	6.18	0.49	7.82	7.28	394.25	409.25	258.73	270.08	156.19	142.3	29.81	36.17	119.41	112.97	67.12	68.04	52.27	44.93	26.87	26.47	12.54	10.78	34.33	44.01
Egyptian standard for p.w.	5		1		6.5-8.5		--------		1000		-------		250		500		350		150		____		____		250	
WHO standard	5		1		6.5-8.5		1500		1000		250		250		350		200		150		80		30		-------	

P.W. = Produced Water from Benha filtered water treatment plant, R.W. = Raw water, N.D. = Not Detected, WHO = World Health Organization

In the raw water, the mean value of sulfate was 34.33 mg/L, while the mean value in the produced water was 44.01 mg/L. The decrease of sulfate in May and June may be attributed on the basis of its uptake by aquatic microorganisms (Nour El-Din, 1985); while the increase of sulfate may be due to the death of microorganisms.

The highest conductivity values of the raw water and the produced water were recorded (468 µS/cm and 470 µS/cm), respectively; while in June 2015, the lowest values were (330 µS/cm and 355 µS/cm), respectively. It was found that the highest values were recorded in October 2015, due to the temperature was high that dissolve the salts and increase the conductivity of water. The decrease of electrical conductivity may be due to presence of phytoplanktons that make the uptake of the dissolved salts (Nour El-Din, 1985).

The highest alkalinity values in the raw water and the produced water were 171.6 mg/L and 160 mg/L, respectively in September 2015; while in June 2015, the lowest alkalinity values in the raw water and the produced water were recorded (136.5 mg/L, 117 mg/L), respectively. These results were in accordance to Ali (2002).

Chemical evaluation of heavy metals of both raw and produced water

The obtained results of heavy metals were expressed in Table 2. In the present study, the mean values of aluminum, cadmium, chromium, copper, nickel, lead, iron, manganese and zinc in Benha Filtered Water Treatment Plant were within the permissible levels of Egyptian Standard, (2007). By the means of high contamination of dissolved lead, copper, nickel and mercury are generated from anthropogenic activities (Komy & El-Samahy, 1995). The other dissolved ions in the Nile are of natural origin.

The highest aluminum values of the raw water and the produced water were in December 2015 (0.17 mg/L and 0.2 mg/L), respectively; while in August 2015, the lowest aluminum values of the raw water and the produced water were recorded (0.1 mg/L and 0.14 mg/L), respectively. Aluminium in high levels may result in Alzheimer's disease (Jekel, 1991).

Iron is found in water in two oxidation states, the oxidized ferric (Fe^{3+}) and reduced ferrous (Fe^{2+}) which is the most active form in biological system. The highest iron values in the raw water and the produced filtered water were 0.47 mg/L in April 2015 and 0.2 mg/L in February 2016, respectively; while the lowest iron values in the raw water and the produced filtered water were 0.03 mg/L in June 2015 and 0.02 mg/L in August 2015, respectively. The Quebec Government of Canada researches about iron recommended concentrations of 1 mg/L for acute toxicity and less than 0.3 mg/L to protect against chronic effects (Guay et al., 2002).

Many nickel salts are water soluble, therefore contamination of water can arise levels as high as 1mg/l have been reported in surface waters (CEC, 1979). High concentrations of nickel in water result in skin allergies and cancer of the respiratory tract (Kasprzak et al., 2003). The average cadmium and nickel values in raw water were 0.13 µg/L and 1.56 µg/L, respectively. Cadmium was not detected in produced filtered water. High concentrations of cadmium may be due to cigarette smoking, that it is not present generally of high concentrations in water (AMAP, 2003).

Chromium is used widely in industrial processes and may enter a water supply through the discharge of wastes. Chromium may exists in water supply in both hexavalent and the trivalent state may occurs in potable water (APHA, 2005).The highest chromium value in raw water was 2 µg /L in April 2015, while the lowest chromium value was 0. 3 µg/ L in August 2015, the highest chromium value in the produced filtered water was 2 µg /L in June 2015; while the lowest chromium value was 0.2 µg / L in October 2015. In Nova Scotia in Canada, raw water samples were analyzed for chromium, the average concentration of chromium was 2.5µg/L, with a maximum value of 4µg/L (Nova Scotia Department of Environment and Labour, 2010).

Lead is very toxic and the degree of lead toxicity depends on pH values, hardness, organic matter, the presence of other metals and the solubility of the metal ion affects on its toxicity in water. Lead in water supply may come from industrial, mine and smelter discharges or from dissolution of old lead plumbing (APHA, 1998). Lead acts by complexing with oxogroup in enzymes and affects virtually all steps of haemosynthesis and propherin metabolism. It inhibits acetylcholine esterase, acid phosphatase,

TABLE 2. Concentration of heavy metals for both raw water and Benha filtered water treatment plant samples

Parameter & month	R.W.	P.W.	R.W.	P.W.	R.W.	P.W.	R.W.	P.W.	R.W.	P.W.	R.W.	P.W.	R.W.	P.W.	R.W.	P.W.	R.W.	P.W.
	Al (mg/l)		Cd (µg/l)		Cr (µg/l)		Cu (µg/l)		Fe (mg/l)		Mn (µg/l)		Ni (µg/l)		Pb (µg/l)		Zn (µg/l)	
February	0.17	0.19	0.2	N.D.	1	0.6	94	5	0.31	0.2	33	3	2.3	1.2	1.4	0.53	10	9.9
April	0.15	0.18	0.15	N.D.	2	0.9	89	N.D.	0.47	0.03	N.D.	4	1.67	1.1	0.9	0.6	20	10
June	0.13	0.16	N.D.	N.D.	0.7	2	N.D.	5	0.03	0.12	4	N.D.	N.D.	1.25	0.6	0.52	20	19.8
August	0.1	0.14	0.1	N.D.	0.3	0.8	9	9	0.24	0.02	7	1	1.9	1.4	0.4	0.5	10	4
October	0.16	0.19	0.2	N.D.	1.4	0.2	N.D.	6	0.22	0.16	44	0.4	1.9	1.32	N.D.	0.56	20	8
December	0.17	0.2	0.13	N.D.	1.2	0.7	9	5	0.16	0.05	37	1	1.56	1.3	0.35	0.59	20	7
Min.	0.1	0.14	N.D.	N.D.	0.3	0.2	N.D.	N.D.	0.03	0.02	N.D.	N.D.	N.D.	1.1	N.D.	0.5	10	4
Max.	0.17	0.2	0.2	N.D.	2	2	94	9	0.47	0.2	44	4	2.3	1.4	1.4	0.6	20	19.8
Average	0.15	0.18	0.13	N.D.	1.1	0.87	50.25	6	0.24	0.1	25	1.88	1.56	1.26	0.61	0.55	16.67	9.78
Egyptian standard		0.2		3		50		2000		0.3		400		20		10		3000
WHO standard		0.2		3		50		-----		0.3		400		------		-----		------

P.W. = Produced water R.W. = Raw water

ATPase, carbonic anhydrase and inhibits protein synthesis (Greenwood & Earnshaw, 1985). The average lead value in raw water and the produced filtered water were 0.61µg/L and 0.55 µg/L, respectively. Death can occur at extremely high levels of lead in water (Tong et al., 2000) .

Manganese is bind with iron minerals and occurs in nodules in ocean, fresh waters and soils. The common aqueous species are the reduced Mn_2 and the oxidized Mn_4. Elevated manganese levels can cause stains in plumbing laundry and cooking utensils. The average cupper, manganese and zinc values in raw water were 50.25 µg/L, 25 µg/L and 16.67 µg/L, respectively; while in the produced filtered water were 6 µg/L, 1.88 µg/L and 9.78 µg/L, respectively. The excessive concentrations of Mn will result in metallic taste in water, staining of different products like clothes, paper and plastics (Homoncik et al., 2010).

In the raw water, the highest copper value was 94µg/L in February 2016; while the lowest value was not detected in June 2015 and October 2015. In the produced water, the highest copper value was 9µg/L in August 2015; while the lowest value was not detected in April 2015. High concentrations of copper lead to problems in neurological system, including Alzheimer's disease and prion diseases (Llanos & Mercer, 2002).

Zinc is an essential trace metal with very low toxicity in humans (Ciubotariu et al., 2015). The highest zinc value in the raw water was 20µg/L in April 2015, June 2015, October 2015 and December 2015; while the lowest value was 10µg/L in February 2016 and August 2015. In the produced water, the highest zinc value was 19.8µg/L in June 2015; while in August 2015, the lowest value was recorded (4µg/L).

Trihalomethanes evaluation of both raw and produced water:

The results in the Table 3 showed that concentration of trihalomethanes in raw water samples was < LOQ (<4), this is due to absence of residual chlorine to combine with organic matter to form trihalomethanes. The average value of trihalomethanes in produced filtered water was within the permissible levels of (Egyptian Standard, 2007) (not more than 100µg/L) (52.77 µg/L).The maximum value of THMs conc. in Benha Filtered Water Treatment Plant was high (63.21µg/L) in December due to an increase in the organic matter occurred with residual chlorine (2.5), as a result high THMs conc.

TABLE 3. Trihalomethanes concentration of both raw water and Benha Filtered Water Treatment Plant samples

Parameter & month	R.W. T.H.Ms conc. (µg/L)	P.W. T.H.Ms conc. (µg/L)
February	< LOQ	55.81
April	< LOQ	44
June	< LOQ	62.15
August	< LOQ	39.7
October	< LOQ	51.77
December	< LOQ	63.21
Min.	< LOQ	39.7
Max.	< LOQ	63.21
Average	< LOQ	52.77
Egyptian standard	100	
WHO standard	-----	
EPA standard	100	
APHA standard	100	

LOQ (Limit of Quantitation) = 4

The microbiological quality of both raw and produced water

The microbiological quality of water was evaluated by monitoring of total bacterial counts and fecal bacteria indicators of pollution in raw water and also in produced water from Benha Filtered Water Treatment Plant in Benha City. The greatest microbial risks are associated with drinking water occur through ingestion of water that is contaminated with human or animal faeces (Cabral, 2010). Wastewater discharges in fresh waters and coastal seawaters are the major sources of fecal microorganisms, including pathogens (WHO, 2008).

Coliforms include the members of Enterobacteriaceae such as *Escherichia coli, Enterobacter aerogenes*, *Salmonella* and *Klebsiella* spp. These Enteropathogenic bacteria in water are responsible for a variety of diseases like cholera, typhoid, dysenteries and bacillary dysentery, in human and livestock (Ashbolt, 2004). Comparison between classical bacterial indicators (total bacterial counts at 22°C and 35°C, total coliforms, fecal coliforms and fecal streptococci) in the raw water and the outlet were expressed in Fig. 1, 2 and 3.

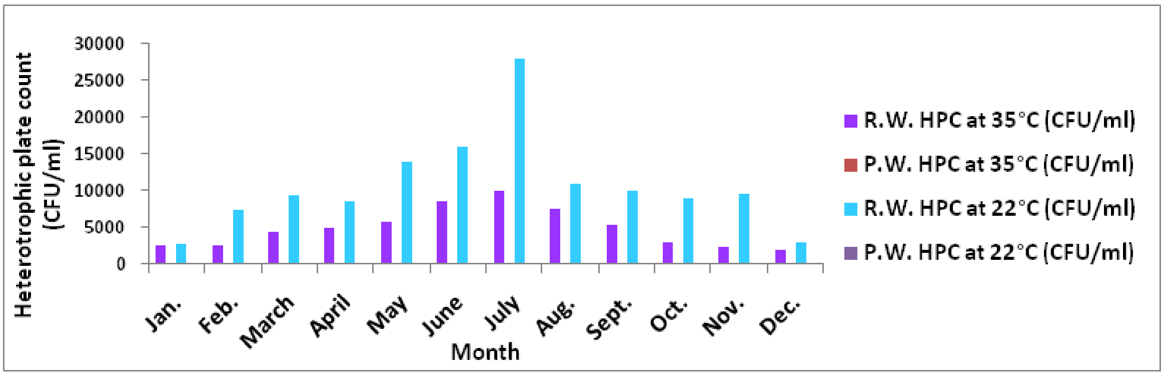


Fig. 1. Histogram showing heterotrophic plate count (HPC) (CFU/ml) at 35°C and 22°C in the raw water and the produced water from Benha filtered water

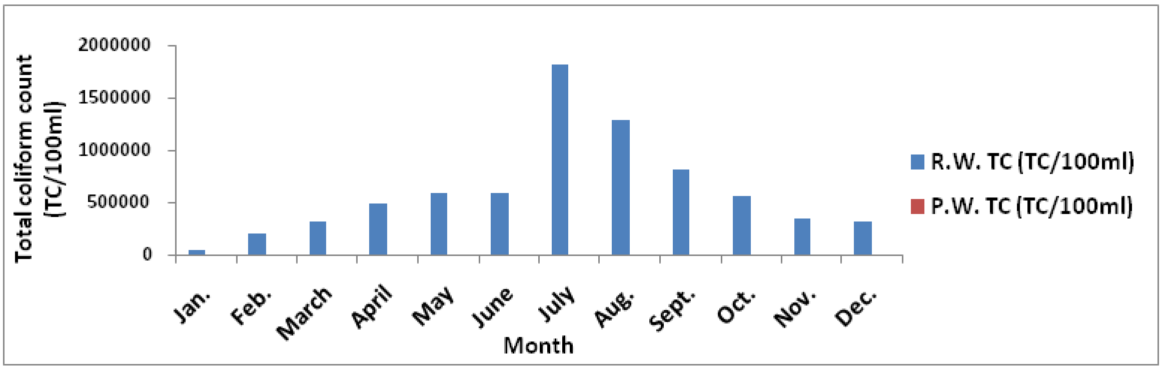


Fig. 2. Histogram showing total coliform bacteria (TC) (TC/100ml) in the raw water and the produced water from Benha filtered water

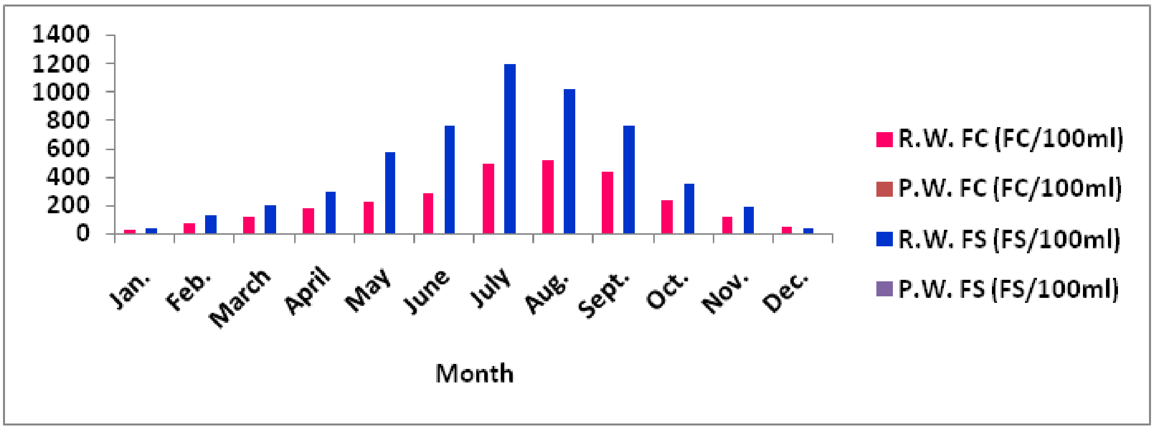


Fig. 3. Histogram showing count of fecal coliform bacteria (FC) (FC/100ml) and fecal streptococci (FS) (FS/100ml) in the raw water and the produced water from Benha filtered water

At 22°C, the highest total count of bacteria in raw water was 28×10^3 CFU/ml in July 2015 and the lowest value was 2.9×10^3 CFU/ml in January 2016. The highest total count of bacteria in produced filtered water was 48 CFU/ml in July 2015 and the lowest value was <1 CFU/ml in January 2016 and February 2016. The Netherlands drinking-water quality standard also set a numerical limit of 100 CFU/ml for heterotrophic bacteria at 22°C (Anonymous, 2001). At 35°C, the highest value in raw water was 10×10^3 CFU/ml in July 2015, while the lowest value was 2.05×10^3 CFU/ml in December 2015. The highest value in filtered water was 15 CFU/ml in July 2015 and August 2015, while the lowest value was <1 CFU/ml in January 2016, February 2016, November 2015 and December 2015.

The average number of total coliform bacteria in raw water was 610.75 ×10^3 TC/100 ml, while no total coliforms were detected in produced filtered water. In Sohag, The value of total coliform in the raw water in hot seasons was from 100 TC/100ml at Sohag site to 80000 TC/100 ml at Tahta; while it varied from 200 TC/100 ml at Dar-Elsalam to 400 TC/100 ml at Tima during cold season (Abd El-Azeiz Heikal, 2012). The average numbers of fecal coliform bacteria and fecal streptococci bacteria in raw water were nearly 229FC/100 ml and 463FS/100 ml. No fecal coliforms and fecal streptococci were detected in the outlet of Benha Filtered Water Treatment Plant.

Thus, the mean values of total viable bacteria at 35°C and at 22°C, total coliforms, fecal coliforms and also fecal streptococci in Benha Filtered Water Treatment Plant were within the permissible levels .The results indicate the safety of tap water according to Egyptian Standard (2007). The Egyptian standard for drinking water declared that potable water must be free from total coliforms, fecal coliforms as well as fecal streptococci in addition total bacterial counts must be less than 50 CFU/ml. Similar results were observed by El-Deeb (1997) who found that drinking water collected from El-Giza, Mostorod and Beni-Suif treatment plants were free from classical bacterial indicators and compatible with Egyptian Standard (2007). Also, nearly compatible results for drinking water collected from El-Dokki, El-Sayda Zeinab, Naser City, Shubbra and Shubbra El-Khima treatment plants were obtained by (Samhan, 1998).

Identification of bacteria

Identification of these bacterial species was carried out using the VITEK® 2 identification card. The microorganisms were not found in Benha Filtered Water Treatment Plant; while, in raw water found *Escherichia coli* and *Enterobacter aerogenes*. This is agree with the results of the raw water in Sohag Governorate,which contains *Salmonella* spp, *Shigella* spp., *E.coli* and *Pseudomonas aeruginosa* (Abd El-Azeiz Heikal, 2012).

Conclusion and Recommendations: By analyzing samples of finished water from Benha Filtered Water Treatment Plant, it was found that the mean values of all samples for all physicochemical, bacteriological, heavy metals and trihalomethanes' parameters were within the Egyptian standard method decree no. 458 / 2007. Detection of the prevalent pathogenic bacteria periodically for the evaluation of drinking water quality in addition to the classical bacterial indicators of water pollution must be performed.

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التقييم الفيزيائي - الكيميائي والبكتريولوجي لمياه نهر النيل ومياه الشرب في مدينة بنها، مصر

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قسم النبات - كلية العلوم- جامعة بنها - بنها و *رئيس قطاع جودة المختبرات - شركة الشرب ومياه الصرف الصحي - القليوبية- مصر.

تم دراسة تقييم جودة مياه الشرب في مدينة بنها، محافظة القليوبية، مصر بين أبريل 2015 إلى مارس 2016 وفقا للجوانب الفيزيائية الكيميائية والبكتريولوجية. وقد تم جمع أربع وعشرين عينة خلال الفصول الأربعة من أماكن مختلفة في مدينة بنها. تم تحليل نوعين من المياه المرشحه ببنها و الماء الخام لنهر النيل وقد أشارت النتائج إلى أن متوسط القيم الفيزيائية الكيميائية ، العناصر الثقيله، التريهالوميثان والعوامل البكتريولوجية في المياه المصفاة ببنها أى المرشحات المعالجه كانت ضمن المعايير المصرية (2007) ومنظمة الصحة العالمية مقارنة بالماء الخام لنهر النيل. وكانت العزلات البكتيرية المهيمنة في عينات المياه الخام لنهر النيل هي *Enterobacter aerogenes* و *Escherichia coli* بينما كانت عينات المياه المصفاة أى المرشحه خالية من البكتيريا المسببة للأمراض و coliforms بنسبة 100٪ .