Drinking water quality and its resources with three different technologies

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ABSTRACT

Surfacewater and ground water are the basic resources of drinking water insuburban area. Three kinds of waters and were monitored to differentiate its suitability for drinking waters through different technologies used to treat. For three waters characterized results, biologicalindicators were moderate loads. While, chemical analyses were recorded different water quality indices (WQI). All of the collected samples showed significant improvements in total solids. The only sample that showed slight increases in total solids was the raw water from the surface compared to the other two groundwater resources. In case of system operating with only chlorination for groundwater, increased dosing loads resulted in a bad taste that required GAC filtration units after. In a GAC/RO system operating in water conditions (<500 TDS), reducing the treatment efficiency loading rate to 45% from 60-80% was important for achieving effluent quality more than 150mg/L during events of low TDS content. The performance of both sedimentation/filtration systems was highly dependent on the biological maturity of the system and surface water quality.

Keywords: **Drinking water; resources; sand filtration; chlorination; Reverse osmosis; metals.**

INTRODUCTION

Egypt is one of the countries facing great challenges, due to its limited water resources represented mainly by its fixed share of the Nile water and its aridity which is the general characteristic of the country (Moghazy et al., 2015).To face these problems of water shortage, the government of Egypt has initiated major programs to improve the performance of the water system of the old lands in the Nile Delta (MWRI 2009).

Water resources quality commonly focuses on nutrients, microbial pollutants, heavy metals, and priority pollutants. However, recent research reveals the presence of a multitude of organic contaminants that significantly affect water quality. These contaminants originate from diverse sources and typically in concentrations that range from ng/L to g/L (Pale et al., 2014). Naturalattenuation and conventional treatment processes are not capable of removing these micropollutants from wastewater and surface and drinking water and are reported to bioaccumulate in macro invertebrates, other organisms in the aquatic food web and humans (Ruhí et al., 2015; Huerta et al., 2015; Annamalai and Namasivayam 2015). Only 1% is available on earth for drinking purpose, agricultural purposedomestic purpose, power generation, industrialconsumption, transportation and waste disposal (Tahir et al., 2008).

Major part of the world's water is seawater, brackish water and groundwater. Approximately, 97.4% of the entire water available on earth is salty and 1.984% is

located in the ice caps and glaciers, while 0.592% is located as groundwater and only 0.014% of the earth's water is available as fresh water (Kalogirou, 2005). Many water-stressed countries are supplementing their fresh water supply with desalinated water to meet their increased water demand caused by population growth, rapid urban sprawl, agriculture development, industrialization,and tourism (Ghaffour et al., 2013).

Ultra-filtration (UF) was found to be cost effective and efficient technique for the removal of suspended solids and bacteria (Arras et al., 2009). The selection of the pre-treatment option is site specific and is mainly based on feed water quality, but in some cases the feed water quality is influenced by seasonal variation (i.e. flood, drought, and climatic impact) which make pre-treatment design more complicated. Forward osmosis (FO) was found to be a feasible pre-treatment option for variable quality feed water and for the feed having high fouling potential. It is capable of providing uniform treated water quality with less fouling potential instead of variable feed quality (Khanzada et al., 2017).

Water pollution not only affects water quality but also cause threats to human health, economic development and social well-being. Groundwater aquifers are highly vulnerable to pollution due to recharging of domestic, industrial and agricultural waste water; therefore, it is significant to control water pollution and monitor water quality (Arivarasi and Ganesan, 2017). Urbanization, industrialization and the unregulated growth of the population have altered the landscape of many urban and peri-urban areas. Changes in land use pattern, local topography and drainage systems directly affect both quality and quantity of groundwater.

The level of contamination tend to be highest during rains, however, the low water volume during dry seasons also result to rise in concentration per water volume for certain contaminants. Therefore, any bacteriological water quality treatment measure needs take into account the intensity of rainfall. This will provide adequate knowledge on the appropriate treatment approach to apply for efficient water quality improvement (Richard et al., 2016).

This study aimed to screen the changes in physical, Chemical and biological parameters during production of drinking waters. Treatment process in raw, clarified, filtered and treated water treatment processes in between conventionally treated methods and new technology (Reversal Osmosis technology) were monitored. Detection of the removal percentage and comparison to Egyptian guidelines were investigated. The effectiveness of this systems was verified by observing the effluent content such as microbial load during an operation periods, total element content (ICP-MS), total suspended Solids (TSS), pH and total dissolved solids (TDS).

MATERIALS AND METHODS

All powdered chemicals were reagent grade (> 99% pure). NaCl, $CaCl_2.2H_2O$, $NaHCO_3$, $FeSO_4.7H_2O$ and $MnSO_4.H_2O$ were supplied by Fisher Scientific (Fair Lawn, NJ). Nitric acid (HNO_3, 67-70%) and $KMnO_4$ were purchased from Alpha chemicals. (India). The commercial sodium hypochlorite (NaOCl, 8% (W/V) available chlorine) bleach solution was diluted to produce a stock solution (120 mg Cl2/L). Ultrapure water (Milli-QTM) from Purelab – ELGA - Veolia, UK,was used to prepare all stock solutions.

Water resources and drinking water treatment plants

Three kinds of water were monitored to differentiate its drinking waters. The first plant was Badr drinking water treatment plant (BDWTP) in El-Berhira governorate, Egypt which abstracts its water from El-Rayah El-Nassary Canal (RNC) intake point of raw surface water of Badr plant is coastal one which attached directly to the plant and transferred water from the river bank to the station. The second type was direct ground water sources which chlorinated before distribution. The last one is compact units that abstract its water from ground water and use reverse osmosis technology for treatment.

Samplingofwater

Raw, clarified, filtered and treated water samples were collected from inside Badr drinking water treatment plant for a full 5 seasons between March, 2017 and June, 2018 following the standard methods for the examination of water and wastewater (APHA, 2005). water samples were weekly collected for various physical, chemical, bacteriological and algal count analyses in addition to experiments for calculation doses of Alum (jar

test) and residual chlorine (break point test). All samples were analyzed about 2 hours from collection and duplicated to get more accuracy.

Physiochemical analyses

The quality of resource water samples was determined after some measurements such as pH (2510 platinum electrode), turbidity as Nephelometric turbidity units (NTU) (2130), chloride (mg/l) (4500 Argentometeric method), total alkalinity(mg/l) (2320B titration method), total Hardness (mg/l) (2340B EDTA titration), silicate (mg/l) (4500C Molybdosilicate method), phosphate(mg/l) (4500D Stannous chloride method), sulfate (mg/l) (4500E Turbidimetric method). Nitrogen forms as free ammonia (mg/l) (4500C Sodium Nitroprossiude method), and Nitrite (4500B colorimetric method) were measured. All the physicochemical analyses were in duplicates and determined by the procedures recommended in the standard methods for the examination of water and wastewater (APHA, 2005).

Microbiological analyses

Water samples were collected in glass bottles that have been cleansed and rinsed carefully, given a final rinse with distilled water, and sterilized by autoclave at 121 ° C for 15 min. Analysis was initiated as soon as possible after collection to minimize changes in bacterial population. The enumeration of total bacterial count (TBC) and total coliform (TC) in water samples was done using the spreading plate and separation membrane techniques. Tryptone glucose yeast agar medium and m-Endo broth (Oxoid, Basingstoke, Hampshire, England) were used for TBC and V, respectively. Additional blanks were prepared to determine contamination of plates, pipets, and room air. Sterility of medium and dilution

water blanks was checked by pouring control plates for each series of samples. Additional controls were prepared to determine contamination of plates, pipets, and room air (APHA, 2005).

Water Quality Index for Drinking

Water Quality Index was calculated based on the relative weight of each physico-chemical parameter. The values of WQI of the samples were found in the range of 27-114 in post-monsoon season while it was 26 -131 in the pre-monsoon season.

Removal Efficiency

It is important to be able to evaluate the rate at which contaminants are removed in order to design the full scale application of the technology (Mousa, 2016). Pollutant removal efficiency was calculated by the following equation:

$$\text{Removal \%} = \frac{C0 - Ct}{C0} * 100 \qquad (1)$$

where Co is the initial pollutant concentration (mg/L) and Ct is pollutant concentration at a defined time during treatment (mg/L).

Data analysis

The collected data on the physic-chemical parameters, density of indicator were appropriately subjected to statistical analysis to find their corresponding mean variations. Graphs and chats were constructed using MS office Excel version 2013 and Statistical Package for Social Sciences (SPSS) version 17 software was used in the analysis. 95% level of significance was used as the critical point(P=<0.05).

RESULTS AND DISCUSSION

In the sand filtration water treatment processes, the coagulation and flocculation processes produce sludge according to the level of the water turbidity. All of the collected samples showed significant improvements in total solids. The only sample that showed slight increases in total solids was the raw water from the RNC compared to the other two resources as shown in Figure 1. In terms of appearance, the treatment system produced significant improvements in every water sample.
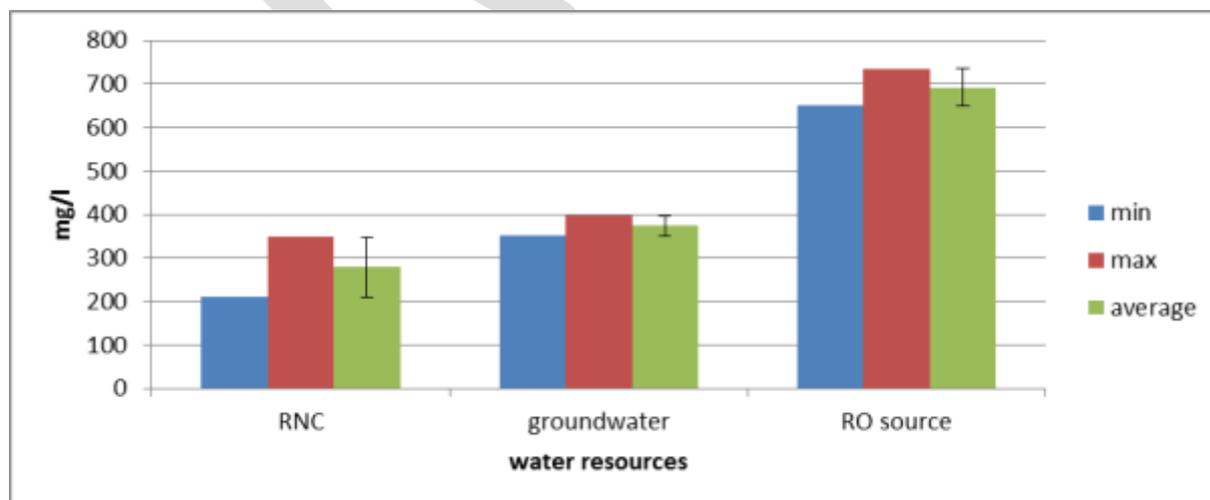

Figure 1: Total dissolved solids of different water resources used for drinking water production through studying period of March, 2017 and June, 2018.

This raw water sample was characterized by a low water turbidity. But the improvement in sedimentation was significant effects.The aluminum sulfate is the most common coagulant used in water treatment plants that depend on surface resources Badr region. It is difficult to manage sludge produced by the treatment plant. However, it can be used in the process to improve the quality of the treated water and reduce the aluminum sulfate doseas shown in Table 1.

Table 1: Physiochemical and biological characterization of surface water abstracted from RNC and removal efficiency of Badr drinking water.

Elements	Raw water		Treated water		Removal %
	Average	SD	Average	SD	
Fecal coliform count (CFU/100 ml)	5.04	38.02	0	0	100
Total Algal count (unit/L)	2265	416	4	3	99.82
Total coliform confirmed test (CFU/100 ml)	479	334	0	0	100
Total bacterial count (CFU/ml)	84	14	0.44	1.08	99.48
Total iron (Fe) (mg / l)	0.08	0.04	0	0	100
Manganese (Mn) (mg / l)	0.09	0.03	0	0	100
Ammonia- N (mg / l)	0.11	0.03	0	0	100
Nitrite-N (mg / l)	0.019	0.027	0	0	100
Turbidity (NTU)	8.52	2.1	0.4	0.08	95.31
Phosphate-P (mg / l)	0.27	0.09	0.2	0.14	25.93
Total alkalinity (CaCO3 / l)	145.81	13.92	126.23	14.67	13.43
pH	7.77	0.24	7.31	0.13	5.92
Total hardness (CaCO3 / l)	149.72	10.83	149.71	10.76	0.0066
Residual chlorine (mg / l)	0	0	2.55	0.36	------
Aluminum (Al) (mg / l)	0	0	0.08	0.01	----------
Calcium hardness (CaCO3 / l)	82.88	9.07	83.03	9.00	-0.18
Electrical Conductivity (EC) (µ S / cm)	387.06	32.02	398.15	32.4	-2.86
Total dissolved solids (TDS) (mg / l)	259.45	21.46	266.68	21.74	-2.78
Silica (mg / l)	5.68	3.13	7.16	2.37	-26.05
Sulfate (SO4) (mg / l)	31.84	4.17	44.76	4.84	-40.57
Chlorides (mg / l)	19.45	3.37	37.86	5.72	-94.65

In this study, the effectiveness of sludge was evaluated at different turbidity levels (low, medium and high turbidity) and coagulant dosage to find optimal operational conditions. The influence of settling time was also studied. A set of Jar test experiments was conducted to find the sludge and aluminum sulfate dosages in order to improve the produced water quality for different turbidity levels. Also, another objective of this study is to provide water treatment operators with a tool that enables to predict and replace, sometimes, the manual method (Jar testing) used in this plant to predict the optimum coagulant doseas shown in Figure 2.
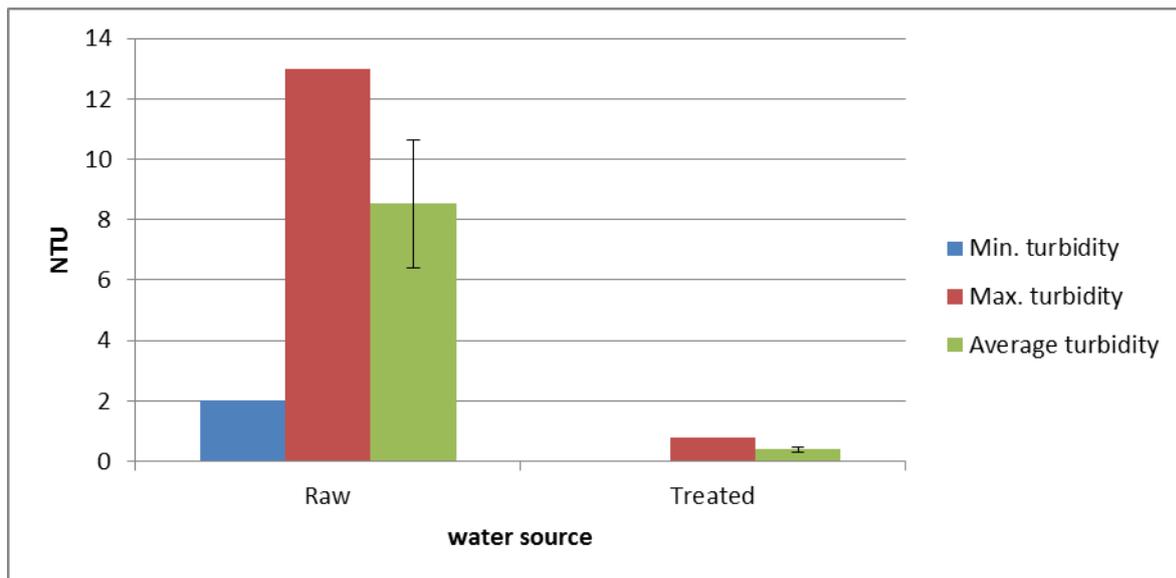
Figure 2: Turbidity of different water sourceof Badr station for drinking water production through studying period of March, 2017 and June, 2018.

Results demonstrated that reusing sludge produced by the treatment plant can improve the quality of the produced water and reduce the aluminum sulfate using (turbidity removal up 99,47%). The aluminum sulfate dosage can be reduced from 40 to 50% according to the turbidity level. Also, it is possible to construct a model using actual process data from water treatment plant located in Meknes, Morocco.

The corrections of manganeseandiron ions were performed by 97.08% and 82.27%, respectively. Through Adsorption of Mn(II) onto MnOx(s)-coated sand which is normally performed in packed bed contactors operated at relatively low HLRs (6-12 m/h) to remove low feed water Mn(II) concentrations (< 0.5 mg/L) (Piispanen and Sallanko, 2010).

Figure 3: Water properties correction as a results of GAC/RO system ofBerkash region, Giza, Egypt stations for drinking water production through studying period of March, 2017 and June, 2018.

Also, results show that this approach can be used in order to improve the quality of treated water and reduce the cost of the produced water by minimizing monitoring expenses granular activated carbon/ reverse osmosis (GAC/RO)equipment operation cost. Thus, this action plan allows the water treatment plant to integrate its environment, be eco-friendly and plays a great role in the sustainable management of water resources and therefore in regional sustainable developmentas shown in Figure 4.
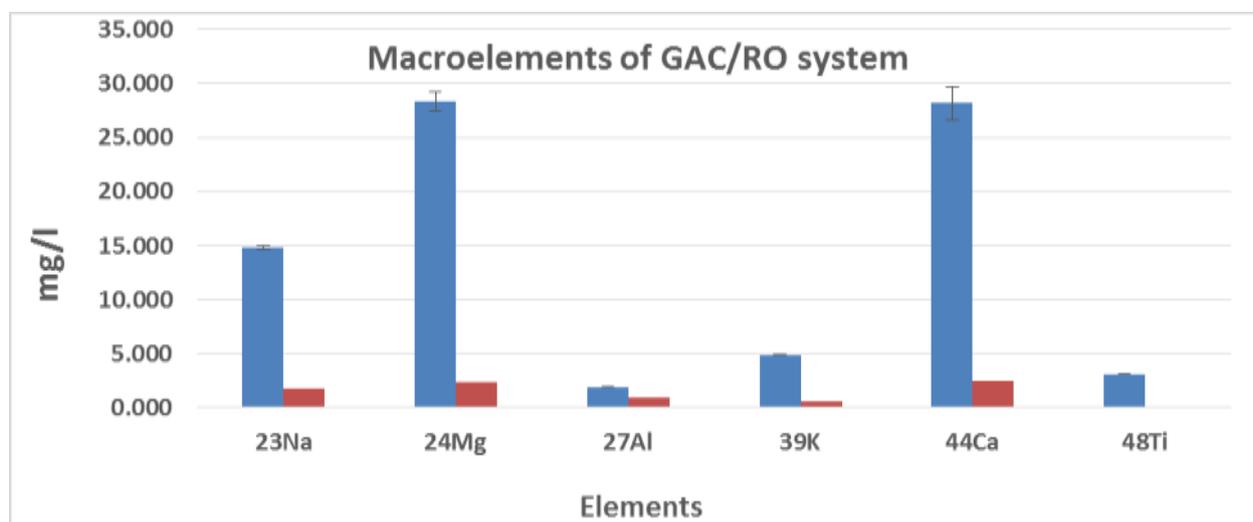

Figure 4: Macroelements composition of water before and after application of GAC/RO system ofBerkash region, Giza, Egypt stations for drinking water production through studying period of March, 2017 and June, 2018.

CONCLUSION

From the results of this study are presented as follow:

1. The resource waters have characterized and the metal concentrations of the surface and all ground waters were low to moderate quality according to classification of Flem et al., (2018).

2. pH and EC were not affected by the filtration for the mostparts. The only exception from this was the GAC/RO samples taken from the low TDS content ground water.

3. The performance of both sedimentation/filtration systems was highly dependent on the biological maturity of the system and surface water quality.

4. With a less TDS ground water contents, the performances of both chlorination and GAC/RO systems were highly efficiency systems.

5. In a GAC/RO system operating in water conditions (<500 TDS), reducing the treatment efficiency loading rate to 45% from 60-80% was important for achieving effluent quality more than 150mg/L during events of low TDS content.

6. In case of system operating with only chlorination for groundwater, increased dosing loads resulted in a bad taste that required GAC filtration units after.

7. In contrast, in a more mature system operating in warm water conditions (up to 37.5 °C), increased chlorine doses up to 2 mg/l resulted in good effluent performance.

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