Nile River Freshwater Quality Assessment at Assiut Governorate

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Abstract

The Nile River is the longest in Africa and is one of the most important sources of freshwater. Water specifications vary along the course of the river, which represents the main source of drinking water in Egypt, with depends on the treatment of raw freshwater by conventional plants to get rid of the main pollutants of freshwater, such as suspended particles (turbidity) and microorganisms, therefore assessment of the characteristics of freshwater of the river over long period and studying it opens many horizons for establishing of new techniques for treating the freshwater.

The main objective of this study is to monitor the Nile River over a period at the study area Assiut-Egypt, as this study shows that the Nile River contains large quantities of bacteria with an average 1645 CFU/ml throughout the year in different seasons those affects the numbers of these bacteria, in addition to the river contains moderated concentrations of total dissolved solids with an average 216 ppm, and the average turbidity is about 4.7 NTU, while the average value of pH was 8.2, as well as confirming the low concentrations of iron as the average was 0.04 ppm, moderate concentrations of chloride as its average was 15 ppm, and low concentrations of ammonia as the average was 0.06 ppm. Therefore, this study is an assessment of the Nile River water specifications to prove that the freshwater required to be treated of the non-complied values of bacteria and turbidity concerning the Egyptian drinking water standards.

Keywords: Freshwater quality, Nile river water, Drinking water treatment, Freshwater bacterial count.

Introduction

The Nile is Africa longest river, and it considered as the world longest river as the Nile is about 6,650 kilometers long [1], with eleven countries in its drainage basin: Tanzania, Uganda, Rwanda, Burundi, the Democratic Republic of the Congo, Kenya, Ethiopia, Eritrea, South Sudan, Republic of the Sudan and Egypt. In particular, the Nile River is the main water source in Egypt.

The White Nile and the Blue Nile are two main tributaries of the Nile. The White Nile is known to be the Nile headwaters and main stream. The Blue Nile, which starts at Lake Tana in Ethiopia and flows into Sudan from the southeast, is the source of the majority of the water, comprising 80% of the water and silt. The two rivers come together just north of Khart, Sudan capital.

The river flows almost entirely north through the Sudanese desert to Egypt, where Cairo is situated on a huge delta and the river empties into the Mediterranean Sea at Alexandria. Since ancient times, the river has been vital to Egyptian culture and Sudanese kingdoms.

Fresh water stocks account for (35 million km3), or just 2.5 percent of the entire water supply in the hydrosphere. In the Antarctic and Arctic areas, a major portion of the fresh water (24 million km3, or 68.7%) is in the form of ice and permanent snow cover. Fresh water lakes and rivers, which provide the majority of human water, hold an average of 90,000 km3 of water, or 0.26

percent of total global fresh water reserves [2]. Only through the water cycle phase in which water from oceans, streams, forests, soil, rivers and reservoirs evaporates, forms clouds, and returns as precipitation can freshwater be replenished. Locally, however, if more freshwater is consumed than is naturally restored by human activities, this can lead to a decreased supply of freshwater from surface and underground sources and can cause significant harm to the surrounding and related ecosystems.

The rise in the world population and the rise in per capita water usage are putting growing pressures on the supply of safe freshwater for limited resources. The World Bank adds that the response by freshwater ecosystems to a changing climate can be defined in terms of three interrelated components: water quality, water quantity or volume and water timing. A transition in one also frequently leads to changes in the other [3]. The availability of freshwater often decreases affected by pollution and subsequent eutrophication.

The most common and widespread health risk associated with drinking water is infectious diseases caused by pathogenic bacteria, viruses, and parasites (e.g., protozoa and helminths). The public health burden is determined by the magnitude of the pathogens-related disease(s), their infectivity and the exposed population. There is a diversity of diseases that can be spread by polluted drinking water [4].

Many studies considered the quality of the Nile River water; that led to there is a continuous degradation of the water quality, because it is not capable to achieve a natural cleansing action [5]. Another study was to see the feasibility of using the Nile water as a source for various activities like suitability for aquatic life and drinking [6]. Also another study where to evaluate the multipurpose uses of water and human activities are intense and also aims to reveal the interrelationships between different physical and chemical parameter studied [7].

This study aims to monitor and assessing the quality of the freshwater in the course of the Nile River over two years in the study area site at Assiut-Egypt of coordinates (latitude 27.175892°-longitude 31.203474°), by collecting Nile River freshwater samples and performing laboratory bacteriological analysis as Heterotrophic Plate Count (HPC) to assess the vitality of bacteria, and other physical and chemical analysis such as turbidity, conductivity, temperature, iron, manganese, ammonia, chlorides, calcium and magnesium ions, then performing statistical analysis of these results to form overall view of the Nile River freshwater quality.

Materials and Methods

Samples collecting

The collection of samples from the course of the Nile River in the study area is relied on the manual method using a plastic container tied to a rope that is lowered to the course of the river in an area of good flow of the current and the analyzes are carried out immediately without the need to preserve the sample.

Analytical techniques

The overall laboratory analytical methods is based on the Standard Methods for the Examination of Water and Wastewater which is a joint publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), as it the biggest reference of the water and wastewater analysis.

Bacteriological analysis performed by using the Heterotrophic plate count spread process, bacteria were counted in raw and treated water inlets, as well as plate samples. 0.1 and 0.5 ml of sample are rotated on solidified plate count agar petri dishes, which are then incubated at 35°C for 48 ± 3 hours. The colonies on the dishes were counted with the dilution factor of withdrawn distributed volumes of samples on petri dishes in mind. In order to provide accurate results, duplicate and blank samples were obtained as quality control measures in this analysi [8].

The physical analysis performed on the raw freshwater to assessment the quality were total dissolved solids (TDS) and turbidity. Total dissolved solids were calculated using the electrical conductivity (EC) process, which is a measure of a solution's ionic activity in terms of its ability to transmit current. Turbidity of the sample was determined using the nephelometric process, which compares the intensity of light scattered by the sample under given conditions to the intensity of light scattered by a standard reference suspension under the same conditions using a turbidimeter instrument [8].

The Chemical analysis performed on the raw freshwater to assessment the quality were pH, chlorides, ammonia and total iron. The pH were measured using an electrochemical cell for pH measurement always consists of an indicating electrode, whose potential is directly proportional to pH, a reference electrode, whose potential is independent of pH, and the aqueous sample to be measured. If all three parts are in contact with each other, a potential can be measured between the indicating electrode and the reference electrode, which depends on the pH of the sample and its temperature [8].

The amount of iron in the sample was measured using the phenanthroline colorimetric process, which involves boiling the solution with acid and hydroxylamine, then treating it with 1, 10-phenanthroline at pH 3.2 to 3.3, and measuring the colorimetric absorbance with a UV-spectroscopy instrument at 510 nm wavelength. Chloride was measured by titrimetric method, which is based on silver nitrate titration of the sample until the endpoint on a pinkish yellow color appearing. Ammonia was analysed using the phenate method as an intensely blue compound, indophenol, which is produced by the reaction of ammonia, hypochlorite, and phenol catalysed by sodium nitroprusside and colorimetrically measured using a UV-spectroscopy instrument at 640 nm wavelength [8].

Table (1) the laboratory experimental performed analysis.

Analysis category	Analysis	Method no. in APHA
Bacteriological	Heterotrophic plate count (HPC)	9215 C
Physical	Total dissolved solids (TDS)	2540 C
	Turbidity	2130 B
Chemical	pH value	4500-H^+
	Iron	3500-Fe B
	Chloride	4500-Cl^- B
	Ammonia	4500-NH_3 F

Results and Discussion

Bacterial viability observation:

Since the examination of bacterial viability by HPC method were experimentally performed about (10) trials among the two years in different seasons to observe the change of the bacterial count over a large time scale, the results were obtained as in Table (2) and expressed in Fig. (1).

Table (2) Heterotrophic plate count of bacteria experiments results.

Date	HPC (CFU/ml)
29/10/2018	1300
23/11/2018	800
28/01/2019	800
29/03/2019	1400
18/05/2019	300
19/11/2019	500
07/12/2019	3000
21/01/2020	1800
22/02/2020	3600
27/02/2020	2950

Fig. (1) Shows the variation of the bacterial count by HPC among the experiments performed period. It is clearly noticed, the change of bacterial count among the experiments period with dependent to the seasons change.

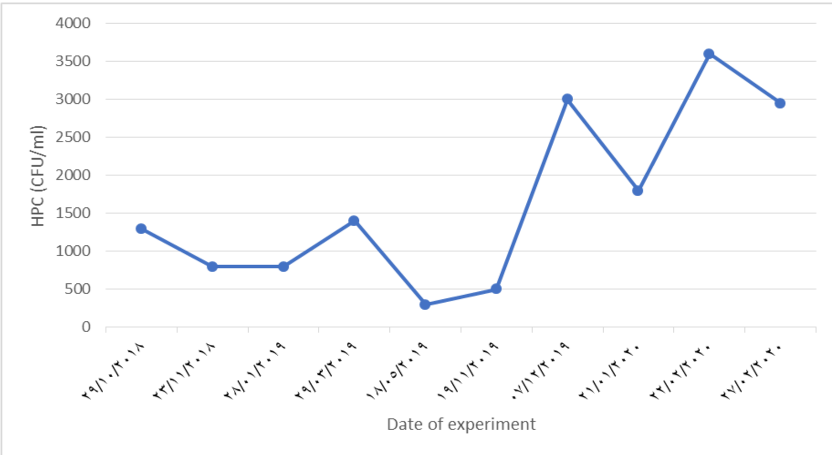

Fig. (1) Heterotrophic plate count versus the period of experiments.

All bacteria that use organic nutrients for growth are classified as heterotrophic bacteria. These bacteria can be found in all kinds of water, food, soil, plants and even the air. Primary and secondary bacterial pathogens, as well as coliforms, are included in this broad definition (Escherichia, Klebsiella, Enterobacter, Citrobacter and Serratia) [9]. The observed HPC results shows that the maximum bacterial count were 3600 (CFU/ml) at the winter season, and shows that the minimum bacterial count were 300 (CFU/ml) at the end of spring season, while the average value of the bacterial count was calculated as 1645 (CFU/ml), all obtained results for Nile River freshwater HPC show massive increment with reference to the established HPC limit in the Egyptian national drinking water standards of the Egyptian health minister decree 458/2007, which must not exceed 50 CFU/ml.

The physical experiments were performed about (26) trials monthly among around two years to observe the change of the physical parameters over a large time scale, the results were expressed in Fig. (2 - a, b).

Fig. (2 - a, b) Show the variation of the physical parameters (total dissolved solids (TDS) and turbidity) among the experiments performed period.

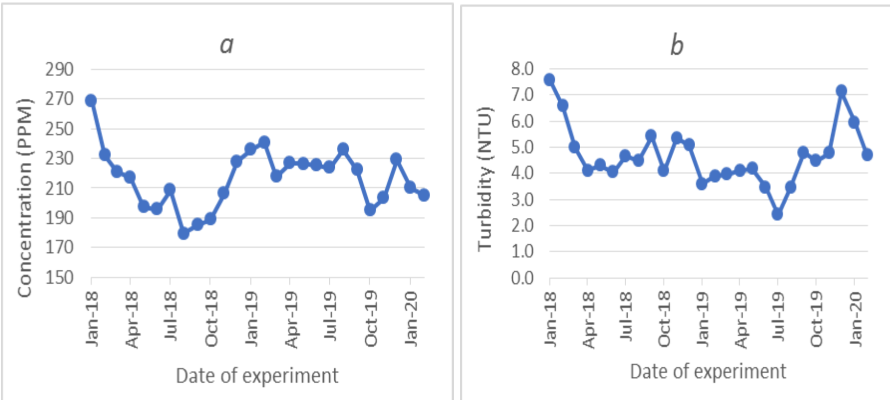

Fig. (2 - a, b) Physical parameters versus the period of experiments.

Total dissolved solids (TDS) expresses the amount of inorganic and organic substances dissolved in water. Inorganic ions involved in natural water involve carbonate, calcium, sulphate, chloride, sodium and other, mostly minor, constituents such as iron, copper, bromide or manganese [10]. Figs. (2 - a) shows the variation of the total dissolved solids in freshwater samples over the experiments period and it was observed that the maximum TDS concentration was 269 ppm, the minimum was 179 ppm, seasonally TDS average results were (231 ppm in winter, 218 ppm in spring, 212 ppm in summer and 200 ppm in autumn) and the average value of TDS was calculated as 216 ppm.

All of the TDS resulted values comply the established limits of the TDS in the Egyptian national drinking water standards of the Egyptian health minister decree 458/2007, which must not exceed 1000 ppm.

While the study of Indices of water quality and metal pollution of Nile River, Egypt obtained seasonally TDS average results as (259 ppm in winter, 186 ppm in spring, 179 ppm in summer and 228 ppm in autumn) with average of 213 ppm over-year of 24 water quality monitoring sites were set up on the main stem of the river, covering 925 km along the Nile River [6].

Turbidity is a measure of complete suspended matter in aqueous solutions, which gives sign of clay, inert particles, and microorganisms [11]. Figs. (2 - b) shows the variation of the turbidity in freshwater samples over the experiments period and it was observed that the maximum turbidity value was 7.6 NTU, the minimum was 2.4 NTU, seasonally turbidity average results were (5.6 NTU in winter, 4.3 NTU in spring, 3.8 NTU in summer, and 4.8 NTU in autumn) and the average value of TDS was calculated as 4.7 NTU.

The obtained turbidity results of the Nile River water freshwater don't comply the established limits of the turbidity in the Egyptian national drinking water standards of the Egyptian health minister decree 458/2007, which must not exceed 1 NTU.

While the study of microbiological and chemical study of another site at El-Gezira, Cairo, Egypt - that northern of our study site by 375 km on the Nile River - obtained seasonally turbidity average results as (11 NTU in winter, 6.8 NTU in spring, 4.0 NTU in summer, and 6.5 NTU in autumn) with average of 7.0 NTU over-year [5].

With Turning to the chemical experiments were performed about (26) trials monthly among around two years - similarly to the physical experiments - to observe the change of the chemical parameters over a large time scale, the results were expressed in Fig. (3 - c, d, e, f).

Fig. (3 - c, d, e, f) Show the variation of the chemical parameters (pH, iron, chloride, and ammonia) among the experiments performed period.

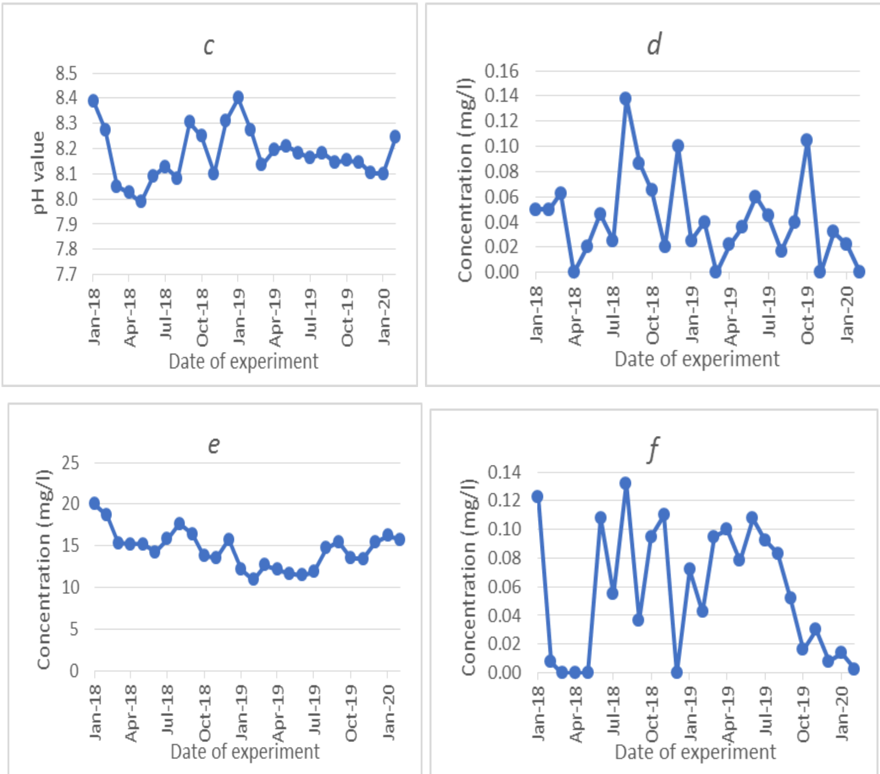

Fig. (3 - c, d, e, f) Chemical parameters versus the period of experiments.

pH is a scale used to specify the acidity or basicity of an aqueous solution [12], Figs. (3 - c) shows the variation of the freshwater pH value over the experiments period and it was observed that the maximum value of pH was 8.4, and the minimum was 8.0, seasonally pH average values were (8.3 in winter, 8.1 in spring, 8.2 in summer, and 8.2 in autumn) while the average value of pH was calculated as 8.2.

All obtained results of pH values comply the established limits of pH in the Egyptian national drinking water standards of the Egyptian health minister decree 458/2007, which must be within range of 6.5 - 8.5.

The study of Water quality assessment of river Nile from Idfo to Cairo obtained seasonally pH average values of Nile River surface water in the midstream as (7.63 in winter, 8.60 in spring, 7.50 in summer, and 7.69 in autumn) with average of 7.90 over-year of 11 water quality monitoring sites on the Nile River stream from Idfo city in the Upper Egypt to the capital city Cairo [7].

Figs. (3 - d) shows the variation of the iron concentrations in the freshwater samples over the experiments period and it was observed that the maximum concentration of iron was 0.14 ppm, and the minimum was nil, seasonally iron concentrations as (0.04 ppm in winter, 0.02 ppm in spring, 0.06 ppm in summer, and 0.06 ppm in autumn) while the average concentration for iron was calculated as 0.04 ppm.

The obtained iron concentrations comply the established limits in the Egyptian national drinking water standards of the Egyptian health minister decree 458/2007, which must not exceed 0.3 ppm.

While the study of microbiological and chemical study obtained seasonally iron concentrations as (0.73 ppm in winter, 0.84 ppm in spring, 0.60 ppm in summer, and 0.83 ppm in autumn) with average of 0.75 ppm over-year [5].

Higher chloride concentrations in potable water cause a salty taste [13]. Figs. (3 - e) shows the variation of the chloride concentrations in the freshwater samples over the experiments period and it was observed that the maximum concentration of chloride was 20 ppm, and the minimum was 11 ppm, seasonally chloride concentrations as (15.6 ppm in winter, 13.7 ppm in spring, 14.5 ppm in summer, and 14.3 ppm in autumn) while the average concentration of chloride was calculated as 15 ppm.

All obtained chloride concentrations comply the established limits of chloride in the Egyptian national drinking water standards of the Egyptian health minister decree 458/2007, which must not exceed 250 ppm.

While the study of Indices of water quality and metal pollution of Nile River, Egypt obtained seasonally chloride concentrations as (17.33 ppm in winter, 12.3 ppm in spring, 11.2 ppm in summer, and 17.82 ppm in autumn) with average of 14.66 ppm over-year [6].

The ammonia ions in rivers freshwater is generated by industrial processes or is released from proteinaceous organic matter and urea [14]. Figs. (3 - f) shows the variation of the ammonia concentrations in the freshwater samples over the experiments period and it was observed that the maximum concentration of ammonia was 0.13 ppm, and the minimum was nil, seasonally ammonia concentrations were (0.03 ppm in winter, 0.05 ppm in spring, 0.10 ppm in summer and 0.06 ppm in autumn) while the average concentration of ammonia was calculated as 0.06 ppm.

All obtained ammonia concentrations comply the established limits of ammonia in the Egyptian national drinking water standards of the Egyptian health minister decree 458/2007, which must not exceed 0.5 ppm.

The study of Water quality assessment of river Nile from Idfo to Cairo obtained seasonally ammonia concentrations of Nile River surface water in the midstream as (0.419 ppm in winter, 0.324 ppm in spring, 0.583 ppm in summer and 0.279 ppm in autumn) with average of 0.40 over-year [7].

Conclusion

The assessment of the Nile River freshwater quality is the main way to establish the targeted pollutants to be removed and the treatment methods to produce drinking water complying the local standards of Egypt as established in Egyptian health minister decree 458/2007.

The experiments results with their implementations shows that the main Nile River pollutants are the bacterial count and the turbidity parameters over the experimented parameters (bacterial count, total dissolved solids, turbidity, pH, iron, chloride and ammonia) as both of bacterial count and turbidity parameters exceeding the established limits of the local drinking standards as the maximum, minimum, and average values.

Eventually, the treatment technologies and methods of producing drinking water from the Nile River freshwater should consider to get deal with the main freshwater pollutants such as bacterial count and turbidity than other pollutants to comply the local drinking water standards.

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الملخص العربي

تقييم جودة المياه العذبة لنهر النيل

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نهر النيل هو الأطول في إفريقيا والعالم وهو أحد أهم مصادر المياه العذبة. تختلف مواصفات المياه على طول مجرى النهر، الذي يمثل المصدر الرئيسي لمياه الشرب في مصر، بالاعتماد على معالجة المياه العذبة الخام بواسطة محطات تقليدية للتخلص من الملوثات الرئيسية بتلك المياه، مثل الجسيمات العالقة (العكارة) و الكائنات الحية الدقيقة، لذلك فإن تقييم خصائص المياه العذبة للنهر على مدار فترة طويلة ودراستها يفتح العديد من الآفاق لتطبيق وإقرار تقنيات جديدة لمعالجة المياه العذبة، ويعد الهدف الرئيسي من هذه الدراسة هو رصد جودة المياه بنهر النيل على مدى فترة بمنطقة الدراسة أسيوط - مصر، حيث توضح هذه الدراسة أن نهر النيل يحتوي على كميات كبيرة من البكتيريا بمتوسط 1645 CFU/ml على مدار العام في مواسم

مختلفة والتي لها تأثير على أعداد هذه البكتيريا باختلاف المواسم، بالإضافة لاحتواء النهر على تركيزات معتدلة من إجمالي المواد الصلبة الذائبة بمتوسط 216 ppm، ومتوسط عكارة حوالي 4.7 NTU ، بينما كان متوسط قيمة الأس الهيدروجيني 8.2 ، وكذلك تركيزات منخفضة من الحديد حيث كان المتوسط 0.04 ppm، وتركيزات معتدلة من الكلوريدات بمتوسط 15 ppm، وتركيزات منخفضة من الأمونيا بمتوسط 0.06 ppm، وعليه فإن تلك الدراسة هي تقييم لمواصفات مياه نهر النيل للتأكيد أن المياه العذبة يتطلب معالجتها من القيم غير المطابقة للبكتيريا والعكارة لمطابقة معايير مياه الشرب المصرية.