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FULL LENGTH ARTICLE

Evaluation of surface water quality and heavy metal indices of Ismailia Canal, Nile River, Egypt

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Abstract Ismailia Canal is one of the most important branches of the Nile River in Egypt. It is the main source of drinking and irrigation water for many cities. Weighted arithmetic method of water quality index (WQI) was used to evaluate the water quality of Ismailia Canal according to drinking, irrigation and aquatic life water utilizations. The objective of the index is to transform complex water quality data into understandable and usable information by the public. The WQI values of Ismailia Canal are good to poor for drinking and aquatic life utilizations, and excellent for irrigation utilization. Metal index (MI) and pollution index (PI) were calculated to assess the contaminations of the canal water with the metals (Al^{+3}, Cd^{+2}. Cu^{+2}, Fe^{+2}, Mn^{+2}, Ni^{+2}, Pb^{+2} and Zn^{+2}). MI and PI values denote the dangerous pollution of the canal water, which is described as seriously at most sites along, in particular for drinking and fisheries utilizations. It may be attributed to the effluents of different industrial wastes arriving at the canal water. Law 48/1982 for the protection of the Nile River and its waterways against pollution must be enforced to prevent the obvious deterioration of the canal water and to improve its quality.

Introduction

Nile River is the main water source for Egypt, the traditional concern with securing sufficient water for Egypt's survival and economic development cannot be overemphasized. At the same time, uncontrolled wastewater discharges are causing immediate and long-term water quality health impacts on the users (Ibrahim et al., 2009). Ismailia Canal is one of the most important irrigation and drinking water resources in Egypt; it was constructed in 1862 to supply drinking water to the villages on the Suez Canal zones and to the workers during digging the Suez Canal Navigation Route (Geriesh et al., 2008). Today it's water is used for irrigation, domestic and industrial uses, it is the principle source of drinking water supply for a great number of Egyptian citizens (about 12 million inhabitants), including those living in the northern part of Great Cairo, Shubra El-Kheima, El Amira, Mattaria, Musturod, Abu-Zaabal, Inchas, Belbeis, Abbasa, Abu-Hammad, Zagazig and El-Tal El-Kabeer, before entering the Suez Canal area as well as industrial purposes (Geriesh et al., 2008).

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The canal is extending for about 128 km long, with about 30–70 m width and 1–3 m depth. In the final developing stage, the canal discharge is about 5,000,000 m^3/day of water for drinking and industrial purposes (El-Haddad, 2005). The canal has its inlet from the Nile at Cairo and runs directly to the east to Ismailia governorate passing Cairo – Kalioubeya – Sharkeya governorates, Ismailia (Stahl and Ramadan, 2008). At Ismailia town it bifurcates into two arms, one to the north (90 Km long) to supply Port Said governorate and the other to the south (about 80 Km long) to Suez governorate (Abdo, 1998) with total surround area of about 108,200 fedden (El-Haddad, 2005; Geriesh et al., 2008) indicating that the canal gains up to 24.06×10^6 m^3 of water from the surrounding low aquifer during the closing period of the High Dam gates, while during the rest of the year, the canal acts as an influent stream losing about 99.6×10^6 m^3 of its water account.

Pollution sources in Ismailia Canal

Owing to industrial and agricultural activities large amounts of untreated urban municipal, industrial wastewater and rural domestic wastes discharge into the Nile River, canals or agricultural drains which become an easy dumping site for all kinds of wastes (Stahl et al., 2009). Ismailia Canal represents the most distal downstream of the main Nile River. Thus its water contains all the proceeded pollutants discharged into the Nile. Ismailia Canal has many sources of pollution which, potentially affects and deteriorates the water quality of the canal (Geriesh et al., 2008). The first source is the upstream portion of the Ismailia Canal (from Cairo to Abu Zaabal, western side) including the largest industrial zones in the region (Shupra El-Kheima, Musturod, Abu Zaabal industrial zones), which include the activities of petroleum, petro gas, iron and steel, Abu Zaabal Fertilizers Company, Alum (Aluminum Sulfate) Company, detergent industries and electric power station. The second source is the water treatment plants which caused dramatic changes in its water quality by throwing waste water rich with Aluminum, Iron and Manganese. In addition to waste disposals seepage from the villages and septic tanks, distributed very close to the canal course and the agricultural effluents, are the major sources of contamination.

Mainly there are four main approaches that can be used to assess the water quality of a water body: (1) water quality index approach, (2) trophic status index approach, (3) statistical analysis approaches of the water quality data such as correlation analysis and (4) biological analysis approaches such as Genetic Algorithms method and other different biological indices (Elshemy and Meon, 2011).

Regular water quality monitoring of the water resources is absolutely necessary to assess the quality of water for ecosystem health and hygiene, industrial use, agricultural use and domestic use (Poonam et al., 2013). The water quality evaluation may be a complicated practice in compound parameters causing numerous anxieties in general quality of water (Bharti and Katyal, 2011).

Studies on heavy metals in rivers, lakes, fish and sediments have been a major environmental focus especially in the last decades (Ali and Fishar, 2005). Water pollution by trace metal ions is one of our most serious environmental problems. Effluents resulting from daily domestic and industrial activities may induce considerable changes in the physical and chemical properties of the Nile river and its Canal. These changes may greatly alter the environmental characteristics of river reaches (El-Sayed, 2011). Heavy metals are regard as serious pollution of aquatic ecosystem because of their environmental persistence and toxicity effects on living organisms (Khalil et al., 2007). In the aquatic environment, the trace elements are partitioned among various environmental components (water, suspended solids, sediments and biota) (Shakweer and Abbas, 2005). The toxicity tests are necessary in water pollution evaluation because chemical and physical measurements alone are not sufficient to assess the potential effects on aquatic biota (Abou El-Naga et al., 2005).

The water quality of Ismailia Canal and distributions of heavy metals were the topics of interested for many authors, (Abdo, 1998; Geriesh et al., 2004; El-Haddad, 2005; Tarek and Ali, 2007; Stahl and Ramadan, 2008; El-Sayed, 2008; Geriesh et al., 2008; Ibrahim et al., 2009; Abdo and El-nasharty, 2010; Abdo et al., 2010, 2012; Youssef et al., 2010; Abd El-Hady and Hussian, 2012; Nassif, 2012; Khalifa, 2014).

Materials and methods

Eleven subsurface water samples were collected seasonally (2013–2014) by a polyvinyl chloride Van Dorn bottle at eleven sites along the Ismailia Canal (Fig. 1). Details of surface water sampling location along with their longitude and latitude are presented in Table 1.

Field measurements

Water temperature, electrical conductivity and pH value were measured in situ, using Hydrolab, Model (Multi Set 430i WTW). The transparency was measured using Secchi-disk (diameter 30 cm).

Laboratory analysis

Water samples were kept in 2 l polyethylene bottles in ice box and analyzed in the laboratory. The methods of analyses are discussed in the American Public Health Association (APHA, 1998) except where noted. Total solids (TS) were measured by evaporating a known volume of well mixed sample at 105 °C. TDS was determined by filtrating a known volume of sample by (GF/C) and evaporating at 180 °C. TSS is direct obtained by subtraction of TS–TDS. Dissolved oxygen (DO) was measured by using the modified Winkler method. Biochemical oxygen demand (BOD) was determined by using the 5 day method. Chemical oxygen demand (COD) was carried out using the potassium permanganate method. Water alkalinity was determined immediately after sample collection using phenolphthalein and methyl orange as indicators. Chloride was measured using Mohr's method and sulfate by turbidimetric methods. Calcium and magnesium were determined by direct titration using EDTA solution, Na^+ and K+ were measured directly using the flame photometer Model "Jenway PFP, U.K.". Concentrations of NO_2-N, NO_3-N, NH_4-N, PO_4-P and SiO_4 were determined using colorimetric techniques with the formation of reddish purple azo-dye, Copper-Hydrazine sulfate reduction, phenate, ascorbic acid molybdate and molybdosilicate methods, respectively. Total phosphorus (TP) was measured as reactive