ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Impact of power plants outlet on Nile River Water Quality ''Case study: El-Kurimat Power Plant, Egypt''

M. M. Khalil[1*], R.M. El-Korashey[2] and I.H. Abd-Elgawad[3]

1, 3 Chemistry Department, Faculty of Science, Beni-Suef University, Beni-Suef, Egypt.
2 National Water Research Center, El-Qanater El-Khariya, Egypt.

Manuscript Info

Manuscript History:

Received: 15 June 2014
Final Accepted: 29 July 2014
Published Online: August 2014

Key words:
Water quality index, Cooling system, Power plant

***Corresponding Author**

M. M. Khalil

Abstract

The aim of this research is to study the impact of El-Kurimat power plant outlet on River Nile water quality through measuring physicochemical, chemical and microbiological contaminants of the inlet and outlet samples of El-Kurimat power plant. Water Quality Index (WQI) of the inlet and outlet samples were investigated by using Egyptian Water Quality Index (EWQI) based on Egyptian guidelines of law 48/1982 amended in 2013, article 49. WQI results of the average inlet and outlet samples showed that the water quality is marginal with values 53% and 48%, respectively (i.e. water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels).

1. Introduction

Steam electric power plants are production facilities of the thermal electric power industry. A steam electric power plant product is electrical energy; its primary raw materials are fuel, air and water. The commercial production of electrical energy requires the utilization and conversion of another form of energy. Present-day steam electric power plants utilize the chemical energy of fossil fuels or the atomic energy of nuclear fuels to produce electrical energy in four stages. The first stage consists of burning the fuel in a boiler unit and converting water into steam with heat from combustion. In the second stage the high- temperature, high-pressure steam enters a turbine where energy in the form of shaft work is removed; the turbine shaft is coupled to a- generator, which converts the mechanical energy into electrical energy. In the third stage the steam leaving the turbine is condensed to water, transferring heat to the cooling medium, which is typically water. Finally, the condensate is reintroduced into the boiler to complete the cycle [1].

Apart from increased temperature, the discharges often contain chemical stress factors in the form of biocides (e.g., chlorine) used for biofouling control [2]. Thus, condenser effluents from coastal power plants have the potential to impart thermal and chemical stress and, therefore, may pose environmental problems to the receiving water body [3].

The main effect of temperature on chemical reactions is that, high temperature may inhibit reversibility. Commonly, increasing of water temperature by an amount of $10^{o}C$ might lead to double the rate of the chemical reaction [4].

Fouling is a very important problem for condensers and heat exchangers. All industrial circuits cooled with natural fresh and marine water are affected by the phenomenon of biological fouling consisting in biofilm growth and settlements of several kinds of living organisms. Biofouling is detrimental to open cooling systems as it causes undesirable effects, such as efficiency loss inside the heat exchanger, clogging of the seawater circuit pipes and reduction in plant reliability over a period of time [5].

Chlorination is the most widely used technique for preventing biological organisms from growing in the cooling circuits of industrial plants [6-8]. Typically, intermittent or continuous chlorine injections are used in order to control biofilm growth in power plant condensers [9].

Due to chlorine has high reactivity with natural organic matter contained in the water may generate by-products (called disinfection by-products (DBPs) such as chloramines and haloforms (trihalomethanes, haloaceto-nitriles, halophenols) which are toxic to aquatic organisms [10, 11]. These individual DBPs or mixtures of DBPs could represent a potential human health risk [12-17].

El-Kurimat thermal power plant was selected and studied to deduce the optimal plant outlet which can help for improving the mixing process to comply with the environmental Egyptian laws.

2. Materials and methods

2.1. Study area

El-Kurimat power steam plant is located on the right bank of the Nile River, 831 km downstream Aswan Dam near to El-Kurimat combined cycle plant II from the north downstream, Egypt. The power plant is located just downstream El Kurimat-island in a reach with several small islands or sand bars. This indicates that there is an intensive local sediment transport and deposition in this region. El-Kurimat power plant consists of two power generation units, with total capacity of 1260 MW. It has a cooling system with surface outfall; the surface discharge cooling system of El-Kurimat Power Plant is 3.46 Mm^3d^{-1}. This is considered 10% of the minimum flow discharge of the Nile River at that site [18]. The width of the outlet channel is approximately 55 m, and outfall depth was found to be 4 m.

2.2. Sample collections

Water samples were collected through July, September, October, December 2013 and April 2014 from inlet (sample 1) and outlet on River Nile (sample 2) for El-Kurimat power plant as shown in map 1. Water samples were collected and preserved according to "Standard Method for Examination of Water and Wastewater" [19]. Temperature was measured in field using standard thermometer, 0 –100^oC.

Physicochemical, chemical and microbiological analysis of the collected water samples were measured in the Central Laboratory for Environmental Quality Monitoring (CLEQM), National Water Research Center (NWRC). Physicochemical and chemical analysis includes pH, Electrical Conductivity (EC), alkalinity, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), trace metals, major anions and cations. Microbiological analysis includes total and fecal coliform.

2.3. Water quality index (WQI)

The WQI, which was developed in the early 1970's, can be used to monitor water quality changes in a particular water course over time, or several water courses [20].

In December 2007 a beta version of the Egyptian Water Quality Index (EWQI), based on the Canadian Council of Ministers of the Environment (CCME) Water Quality Index (WQI) was developed. The CCME WQI [21] model consists of three measures of variance (scope, frequency and amplitude) [22]. These three measures of variance combine to produce a value between 0 and 100 represents the overall water quality, thus ranking it into one of the following five categories as in Table 1:

In this study the inlet and outlet on River Nile for El-Kurimat power plant have been evaluated by using Egyptian Water Quality Index (EWQI) based on Egyptian guidelines of law 48/1982 amended in 2013, article 49.

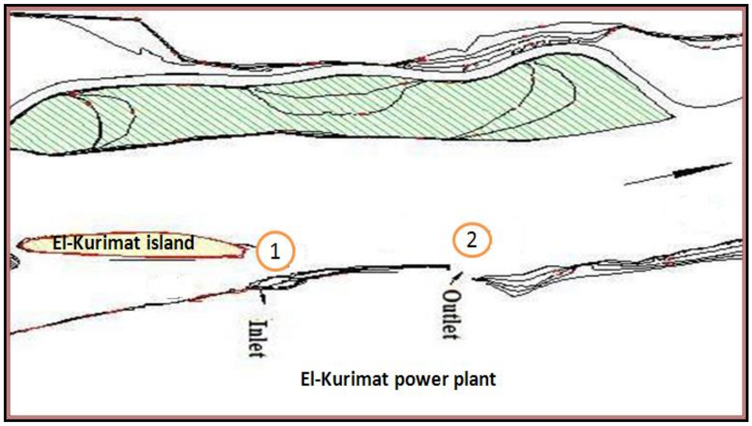

Figure 1 Map showing the inlet and outlet on River Nile at El-Kurimat power station plant.

Table 1 EWQI categories.

EWQI Value	Rating	Remarks
95 - 100	Excellent	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
80 – 94	Good	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
65 – 79	Fair	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
45 – 64	Marginal	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
0.0 – 44	Poor	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

3. Results and Discussion

3.1. Impact of cooling system outlet

The water quality analysis results for El-Kurimat power plant inlet (as reference point) were compared to the outlet to evaluate the impact on River Nile water quality.

Physicochemical Analyses

Temperature

Results illustrated in Figure 2 showed that the outlet temperature was always above the inlet temperature where this increase in temperature ranged between 3-6.5^{o}C with an average 4.5^{o}C which may be attributed to cooling the steam in condenser which promote raising the temperature above the ambient [23].

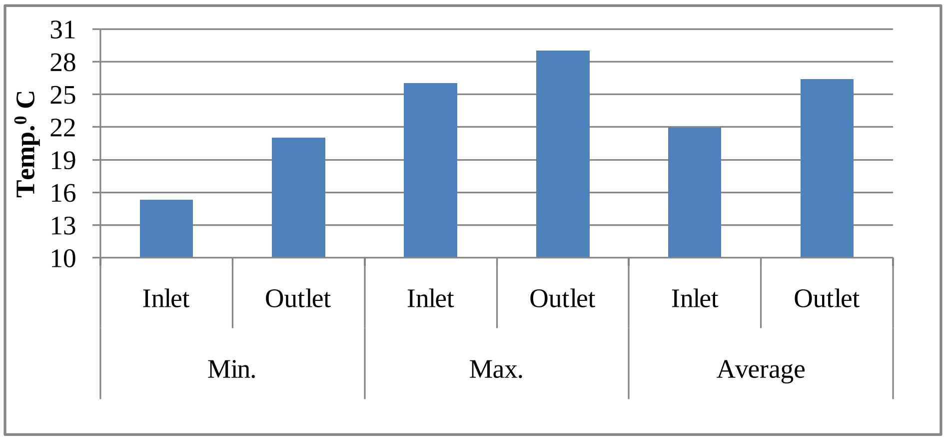

Figure 2 The minimum, maximum and average values of the temperature for inlet and outlet El-Kurimat power plant on River Nile.

pH

Figure 3 showed that the pH values at the outlet of the power plant on River Nile sample ranged between 7.74-8.65 with an average 8.09 were increased slightly compared to the inlet sample ranged between 7.64-8.53 with an average 8.0. However, those values were still within the permissible limits of law 48/1982 amended in 2013, article 49 (6.5–8.5).

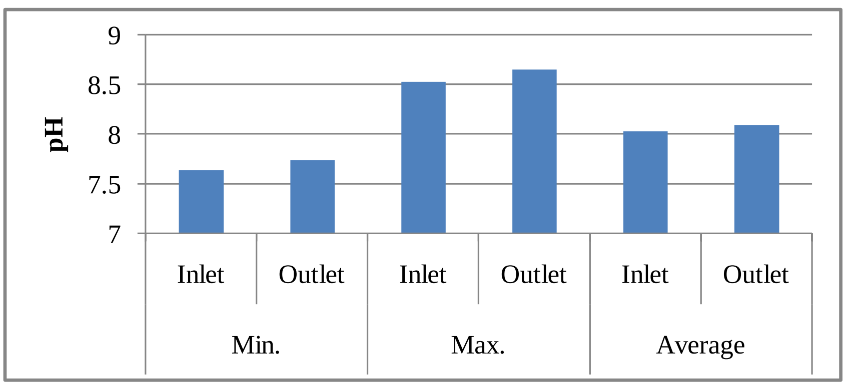

Figure 3 The minimum, maximum and average values of the pH for inlet and outlet El-Kurimat power plant on River Nile.

Total alkalinity

Total alkalinity values at the outlet of the power plant on River Nile sample were in the range 93-170 mg/l with an average 137 mg/l. These values were decreased slightly compared to the inlet sample ranged between 135-165 with an average 150 mg/l. This may be attributed to precipitation of calcium as calcium carbonate at condenser tubes. The results were illustrated in Figure 4.

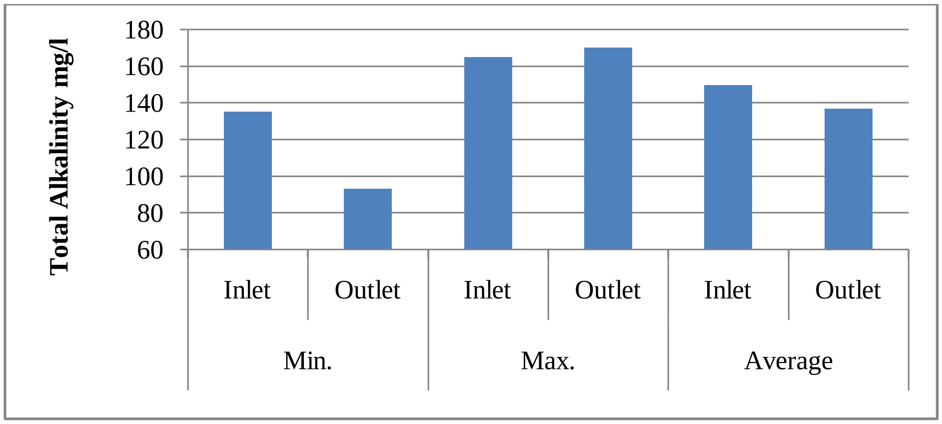

Figure 4 The minimum, maximum and average values of the total alkalinity for inlet and outlet El-Kurimat power plant on River Nile.

Total dissolved solids (TDS) and electrical conductivity (EC)

Results illustrated in Figure 5 showed that the TDS and EC values at the outlet of the power plant on River Nile sample ranged between 208-284 mg/l and 0.33-0.44 mmhos/cm with an average 237 mg/l and 0.37 mmhos/cm were decreased slightly compared to the inlet sample ranged between 215-285 mg/l and 0.34-0.45 mmhos/cm with an average 241 mg/l and 0.378 mmhos/cm, respectively, which may be attributed to precipitation of mineral salts with inverse solubility (decreasing solubility with increasing temperature), such as calcium carbonate, because they have an increased likelihood of precipitation within the hottest portion of the cycle, i.e. within the condenser tubes [24], TDS values were within the permissible limits of law 48/1982 amended in 2013, article 49 (less than 500 mg/l).

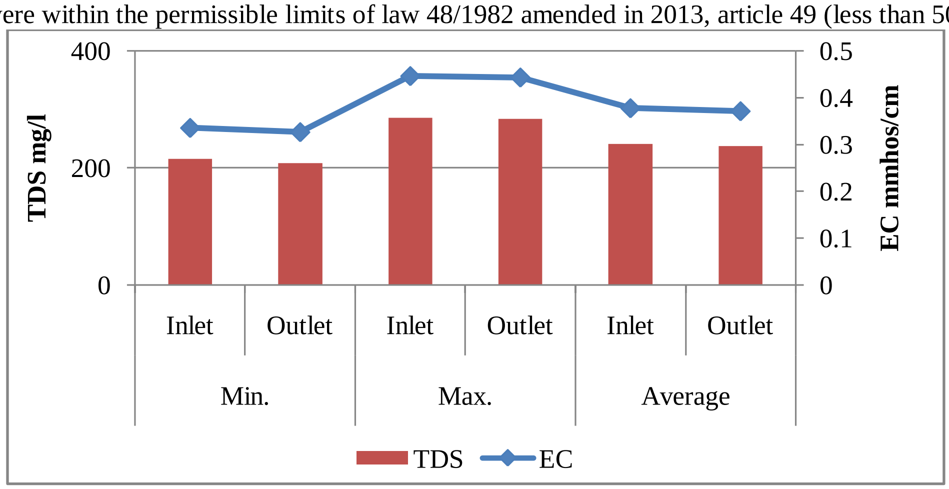

Figure 5 The minimum, maximum and average values of the TDS and EC for inlet and outlet El-Kurimat power plant on River Nile.

Biological oxygen demand (BOD)

Figure 6 showed that the BOD at the outlet of the power plant on River Nile sample values ranged between 1-7 mg/l with an average 2.5 mg/l were not significantly changed compared to the inlet sample ranged between 1-3 mg/l with an average 2.25 mg/l which indicate that those values were within the permissible limits of law 48/1982 amended in 2013, article 49 (less than 6 mg/l).

Chemical oxygen demand (COD)

Results illustrated in Figure 6 showed that COD values at the outlet of the power plant on River Nile sample ranged between 2-15 mg/l with an average 6.3 mg/l were decreased compared to the inlet sample where it ranged between 3-20 mg/l with an average 9.3 mg/l. This may be attributed to injection of chlorine which is used as a biofuling [6-8]. After chlorine injection, COD decrease [25]. These values were within the permissible limits of law 48/1982 amended in 2013, article 49 (less than 10 mg/l).

It is noted that the relatively higher COD values at inlet may be attributed to the presence of organic matter as a result of the resin escape [26] used in water softening in El-Kurimat II located before our study area. The COD is considered an appropriate index for showing the amount of organics in water [27].

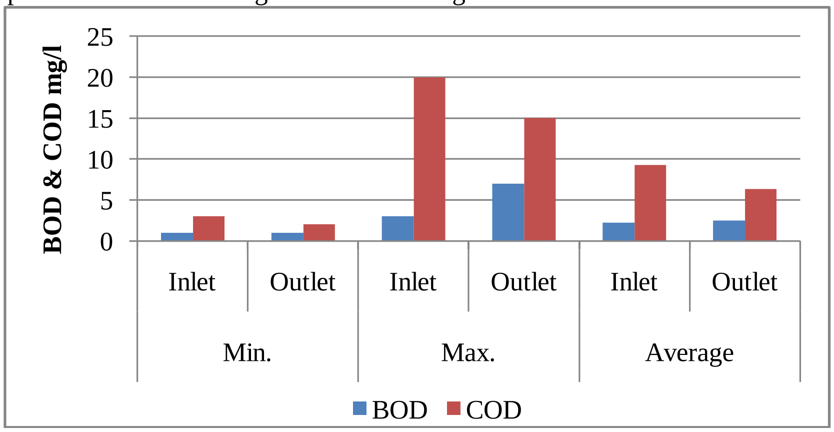

Figure 6 The minimum, maximum and average values of BOD and COD for inlet and outlet El-Kurimat power plant on River Nile.

Major cations and anions

Minimum, maximum and average values for major cations (calcium, potassium, magnesium, and sodium) and major anions (chloride, nitrate, sulphate and fluoride) were calculated for El-Kurimat power plant outlet water samples on River Nile and compared to inlet and tabulated in Table 2.

Table 2 Minimum, maximum and average of the major cations and anions for inlet and outlet El-Kurimat power plant on River Nile.

Parameter	Unit	Inlet			Outlet		
		Min.	Max.	Aver.	Min.	Max.	Aver.
Ca	mg/l	34.82	44.08	38.4	34.16	39.53	36.9
Mg	mg/l	9.44	14	11.7	9.79	13.7	11.9
K	mg/l	2.4	7	4.1	3.74	8	5.8
Na	mg/l	19.4	33	22.58	17	34	21.98
Cl	mg/l	15.1	21.9	18.06	14.5	52	23.82
NO_3	mg/l	1.4	6.2	3.18	1.5	6.1	3.26
SO_4	mg/l	21	48	29.86	20	57	30
F	mg/l	n.d	0.5	0.35	n.d	0.26	0.23

n.d: Not detected

For major cations, the results showed that the magnesium and sodium values at the outlet of the power plant on River Nile sample ranged between 9.79-13.70 and 17.00-34.00 mg/l with an average 11.9 and 21.98 mg/l, respectively. These values were not significantly changed compared to the inlet sample ranged between 9.44-14 and 19.40-33.00 mg/l with an average 11.7 and 22.58 mg/l, respectively.

Calcium values at the outlet of the power plant on River Nile sample ranged between 34.16-39.53 mg/l with an average 36.9 mg/l. These values were decreased slightly compared to the inlet sample ranged between 34.82-44.08 mg/l with an average 38.4 mg/l. This may be attributed to raising the temperature where the precipitation of mineral salts is particularly a concern in the case of minerals with inverse solubility (decreasing solubility with increasing temperature), such as calcium carbonate, because they have an increased likelihood of precipitation within the hottest portion of the cycle, i.e. within the condenser tubes [24].

Potassium values at the outlet of the power plant on River Nile sample ranged between 3.74-8.00 mg/l with an average 5.79 mg/l. These values were increased slightly compared to the inlet sample ranged between 2.4-7.00 mg/l with an average 4.1 mg/l.

For major anions, the results showed that the sulphate and nitrate values at the outlet of the power plant on River Nile sample ranged between 20-57 mg/l and 1.5 -6.1 mg/l with an average 30 and 3.26 mg/l, respectively. These values were not significantly changed compared to the inlet sample ranged between 21-48 mg/l and 1.4-6.2 mg/l with an average 29.86 and 3.18 mg/l which indicate that sulphate values were within the permissible limits of law 48/1982 amended in 2013, article 49 (less than 200 mg/l) while nitrate values violate the permissible limits of law 48/1982 amended in 2013, article 49 (less than 2 mg/l).

It is noted that the nitrate values at inlet violet the permissible limit may be attributed to leaching or runoff from agricultural land or contamination from human or animal wastes [28, 29] or may be from Wastewater Treatment Plant (WWTP) in El-kurimat power plant II which located before our study area discharges that contain nitrite as corrosion inhibitor or ammonia which is used to control the pH of boiler.

Fluoride values at the outlet of the power plant on River Nile sample ranged between non detected-0.26 mg/l with an average 0.23 mg/l. These values were decreased slightly compared to the inlet sample ranged between non detected-0.5 mg/l with an average 0.35 mg/l. This indicates that those values were within the permissible limits of law 48/1982 amended in 2013/2013, article 49 (less than 0.5 mg/l).

Chloride values at the outlet of the power plant on River Nile sample ranged between 14.50-52.00 mg/l with an average 23.82 mg/l. These values were increased slightly compared to the inlet sample ranged between 15.1-21.90 mg/l with an average 18.06 mg/l, may be attributed to injection of chlorine (the chlorine hydrolysis in water to form chloride [30].

Trace metals

The minimum, maximum and average for sixteen trace metals (aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, tin, vanadium and zinc) were calculated for El-Kurimat power plant outlet water samples on River Nile and compared to inlet, tabulated in Table 3. Eight trace metals (antimony, arsenic, cadmium, chromium, cobalt, selenium, tin and vanadium) values were below the detection limit of the instrument.

Table 3 Minimum, maximum and average of the trace metals for inlet and outlet El-Kurimat power plant on River Nile.

Parameter	Unit	Inlet			Outlet		
		Min.	Max.	Aver.	Min.	Max.	Aver.
Al	mg/l	n.d	0.189	0.142	n.d	0.2	0.155
Sb	mg/l	n.d	n.d	n.d	n.d	n.d	n.d
As	mg/l	n.d	n.d	n.d	n.d	n.d	n.d
Ba	mg/l	0.034	0.058	0.050	0.015	0.063	0.042
Cd	mg/l	n.d	n.d	n.d	n.d	n.d	n.d
Cr	mg/l	n.d	n.d	n.d	n.d	n.d	n.d
Co	mg/l	n.d	n.d	n.d	n.d	n.d	n.d
Cu	mg/l	0.024	0.139	0.086	0.038	0.122	0.089
Fe	mg/l	n.d	0.292	0.154	n.d	0.794	0.458
Pb	mg/l	n.d	0.139	0.056	n.d	0.235	0.092
Mn	mg/l	n.d	n.d	n.d	n.d	0.027	0.025
Ni	mg/l	n.d	0.646	0.384	n.d	2.38	0.862
Se	mg/l	n.d	n.d	n.d	n.d	n.d	n.d

Sn	mg/l	n.d	n.d	n.d	n.d	n.d	n.d
V	mg/l	n.d	n.d	n.d	n.d	n.d	n.d
Zn	mg/l	n.d	0.2	0.104	n.d	0.245	0.121

n.d: Not detected

It is noted that the maximum and average values of copper, lead, nickel and zinc violet the limits at inlet sample. This can be attributed to discharging El-Kurimat power plant II and the WWTP (in El-Kurimat power plant II located before our study area) or decay of phytoplankton and other aquatic plants which working as metal accumulators [31]. In addition, the increase in density of boats and ships, which discharge its effluent directly to the Nile containing high amount of Pb in both the dissolved and particular phases [32, 33] may be considered.

Microbiological contaminants

Minimum, maximum and average values of the total coliform (TC) and fecal coliform (FC) were calculated for El-Kurimat power plant outlet water samples on River Nile and compared to inlet and tabulated in Table 4.

Table 4 Minimum, maximum and average of the total and fecal coliform for inlet and outlet El-Kurimat power plant on River Nile.

Parameter	Unit	Inlet			Outlet		
		Min.	Max.	Aver.	Min.	Max.	Aver.
Total coliform	CFU/100ml	170	$128x10^2$	2794	108	$210\ x10^2$	4380
Fecal coliform	CFU/100ml	70	$82\ x10^2$	1708	22	$8\ x10^2$	232

TC values at the outlet of the power plant on River Nile sample ranged between $108\text{-}210x10^2$ CFU/100 ml with an average 4380 CFU/100 ml were significantly high compared to the inlet sample ranged between $170\text{-}128x10^2$ CFU/100 ml with an average 2794 CFU/100 ml.

FC values at the outlet of the power plant on River Nile sample ranged between $22\text{-}8x10^2$ CFU/100 ml with an average 232 CFU/100 ml were significantly low compared to the inlet sample where ranged between $70\text{-}82x10^2$ CFU/100 ml with an average 1708 CFU/100 ml. The changes for TC and FC may be attributed to the injection of chlorine which is used to decrease total and fecal coliform [34]. In El-Kurimat power plant for cooling system pulse chlorination was used which promotes decreasing in FC but with raising temperature the TC increase.

3.2. WQI of inlet and outlet of El-Kurimat power plant

pH, BOD, COD, nitrate, sulphate, total dissolved solids (TDS), arsenic, cadmium, chromium, copper, iron, manganese, fluoride, lead, selenium, nickel and zinc are used to calculate the Egyptian Water Quality Index (EWQI) for the inlet and outlet El-Kurimat power plant, illustrated in Figure 7 and tabulated in Table 5.

It was found that the WQI at inlet and outlet of El-Kurimat power plant is about 54 % and 48 %, respectively which was classified as marginal surface water (i.e. water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels) that indicates a slight negative impact of El-Kurimat power plant.

Table 5 WQI values for inlet and outlet El-Kurimat power plant.

Data Summary	Inlet El-Kurimat power plant	Outlet El-Kurimat on River Nile
WQI	53	48
Categorization	Marginal	Marginal
F1 (Scope)	29	29
F2 (Frequency)	29	29
F3 (Amplitude)	70	80

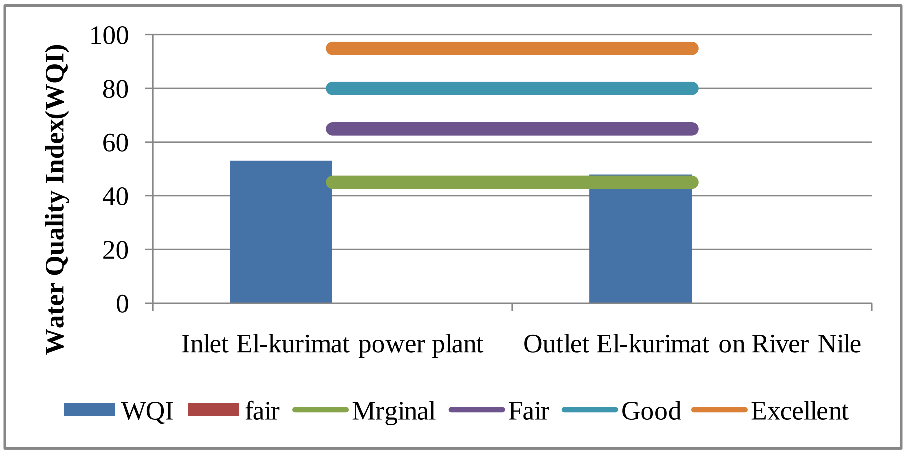

Figure 7 WQI categorization of inlet and outlet El-Kurimat power plant.

4. Conclusion

The present study concluded that the negative impact of El-Kurimat power plant on River Nile water quality is slight where the WQI at inlet and outlet of El-Kurimat power plant is about 53 % and 48 %, respectively which was classified as marginal surface water (i.e. water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels).

References

[1] Mohsen, M. S., 2004.Treatment and reuse of industrial effluents: Case study of a thermal power plant. Desalination J., 167:75.

[2] Morgan III., R.P., and Carpenter, E.J., 1978. Biocides. In: Schubel, J.R., Marcy, Jr., B.C. (Eds.), Power Plant Entrainment—A Biological Assessment. Academic Press, Inc., New York, p: 96.

[3] Krishnakumar, V., Sastry, J. S., and Swamy, G. N., 1991. Implication of thermal discharges into the sea—a review. Indian Environmental Protection J., 11(7): 525.

[4] Hem, J. D., 1985. Study and interpretation of the chemical characteristics of natural water, 3rd ed. US Geological Survey Water Supply Paper.

[5] Muller-Steinhagen, H., 2000. Heat Exchanger Fouling Mitigation and Cleaning Technologies, Publico, Publ., Essen, D, Germany, p: 2.

[6] Jensen, L. D. (Ed.), 1977. Biofouling control mechanisms: technology and ecological effects. Marcel Dekker, New York, p: 113.

[7] Opresko, D. M., 1980. Review of the open literature on the effect of chlorine on aquatic organisms. Electric Power Research Institute, Palo Alto, CA, EA-1491.

[8] Rajagopal, S., Van der Velde, G. and Jenner, H. A., 2010. Chlorination for Dreissena polymorpha control: old war-horse for the new pest? In: Van Der Velde G, Rajagopal S, Bij de Vaate A (Eds) The Zebra mussel in Europe. Backhuys Publishers, Leiden, p: 417.

[9] Cristiani, P. and Giancola, U., 2000. In: H. Muller-Steinhagen (Ed.), Heat Exchanger Fouling Mitigation and Cleaning Technologies, Publico, Publ., Essen, D, p: 334.

[10] Jenner, H. A., Taylor, C. J. L., Van Donk, M., and Khalanski, M., 1997. Chlorination by-products in chlorinated cooling water of some European coastal power stations, Marine Environmental Research J., 43 (4): 279.

[11] Allonier, A.-S., Khalanski, M., Camel, V.â., and Bermond, A., 1999. Characterization of chlorination by-products in cooling effluents of coastal nuclear power stations. Marine Pollution Bulletin J., 38 (12): 1232.

[12] Cancho, B., Ventura, F., Galceran, M., Diaz, A., and Ricart, S., 2000. Determination, synthesis and survey of iodinated trihalomethanes in water treatment processes. Water Research J., 34 (13): 3380.

[13] Simmons, J. E., Richardson, S. D., Speth, T. F., Miltner, R. J., Rice, G., Schenck, K. M., Hunter III, E. S., and Teuschler, L. K., 2002. Development of a research strategy for integrated technology-based toxicological and chemical evaluation of complex mixtures of drinking water disinfection byproducts. Environ. Health Perspect., 110: 1013.

[14] Richardson, S. D., Thruston, A.D., Rav-Acha, C., Groisman, L., Popilevsky, I., Juraev, O., Glezer, V., McKague, A. B., Plewa, M. J., and Wagner, E. D., 2003. Tribromopyrrole, brominated acids and other disinfection byproducts produced by disinfection of drinking water rich in bromide. Environmental Science and Technology J., 37 (17): 3782.

[15] Plewa, M. J., Wagner, E. D., Richardson, S. D., Thruston, A. D., Woo, Y. T., and Mckague, A. B., 2004. Chemical and biological characterization of newly discovered iodoacid drinking water disinfection by-products. Environmental Science and Technology, 38 (18): 4713.

[16] Richardson, S. D., 2005. New disinfection by-product issues: emerging DBPs and alternative routes of exposure. Global NEST J., 7 (1): 43.

[17] Krasner, S. W., Weinberg, H.S., Richardson, S. D., Pastor, S. J., Chinn, R., Sclimenti, M. J., Onstad, G. D., and Thruston, A. D., 2006. Occurrence of a new generation of disinfection byproducts. Environ. Sci. Technol., 40 (23): 7175.

[18] Hydraulic Research Institute (HRI), 2003. Hydraulic modal design of El-Kurimat power plant. Technical report Delta barrages. Egypt.

[19] American Public Health Association (APHA), 1998. "Standard methods for the examination of water and wastewater" 20th ed., Washington D.C.

[20] Zaghloul, S. S. and Elwan, H., 2011. "Water Quality Deterioration of Middle Nile Delta Due To Urbanizations Expansion", Egypt, Fifteenth International Water Technology Conference, IWTC-15, Alexandria, Egypt.

[21] Canadian Council of Ministers of the Environment (CCME), 2001. Canadian water quality guidelines for the protection of aquatic life: CCME Water Quality Index 1.0, User's Manual. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

[22] Khan, A. A., Abdel-Gawad, S., and Khan, H., 2008. "A real Time Water Quality Monitoring Network and Water Quality Indices for River Nile", in 13th IWRA world water congress.

[23] Poornima , E. H. , Rajadurai , M. , Rao , T. S. , Anupkumar , B. , Rajamohan, R. , Narasimhan , S. V. , Rao , V. N. R. , and Venugopalan, V. P., 2005. Impact of thermal discharge from a tropical coastal power plant on phytoplankton. Thermal Biology J., 30 (4): 307.

[24] Maulbetsch J., 2003. Use of degraded water sources as cooling water in power plants. Palo Alto (CA): EPRI; 2003 Oct. Report No.: 100539.

[25] Metcalf and Eddy Inc., 1979. Wastewater Engineering Treatment and Reuse, (a) 4th ed., Chapter 12: Disinfection Process and Chapter 6: Chemical Unit Process Tata McGraw-Hill (2003) and (b) 2nd ed., Chapter 7: Chemical Unit Processes.

[26] Soltan, M. E., 1995. Effect of Kima drains wastewaters on Nile River waters. Environment International J., 21 (4): 459.

[27] Madaeni, S. S., and Mansourpanah, Y., 2006. Screening membranes for COD removal from dilute wastewater, Desalination J., 197 (1–3): 23.

[28] Ayers, R. S. and Wescot, D. W., 1994. Water quality for agriculture, FAO Irrigation and Drainage. Rome, Italy, p: 29.

[29] WHO, 2006. Guidelines for drinking-water quality, incorporating first addendum. Recommendations. 3rd ed. Geneva, 1: 515.

[30] Deborde, M., and Von Gunten, U., 2008. Reactions of chlorine with inorganic and organic compounds during water treatment—Kinetics and mechanisms: A critical review. Water research J., 42: 13.

[31] Harrison M. R. and De Mora J. D., 1996. Introductory chemistry for environ-mental science Cambridge University, Press. p: 301.

[32] Moon, C., Lee, Y., and Yoon, T., 1994. Variation of Trace Cu, Pb and Zn in Sediment and Water of an Urban Stream Resulting from Domestic Effluents. Water Research J., 28 (4): 985.

[33] Ibrahim, S., and Tayel, I., 2005. "Effect of Heavy Metals on Gills of Tilapia Ziilli Inhabiting the River Nile Water (Damietta Branch and El-Rahawey Drain)," Egyptian Journal of Aquatic Biology & Fish, 9 (2): 111.

[34] Al-Hashimi, M. A. I, Mahdi, A.H., and Kadhim, R. J., 2013. The effect of water treatment stages in Al-wathba water treatment plant on the bacterial growth (applied study). European Scientific J., 9(9).