Egypt.J.Chem. **Vol. 62**, No. 6. pp. 1117 - 1129 (2019)

Egyptian Journal of Chemistry
http://ejchem.journals.ekb.eg/

Assessment of Surface Water Quality, Raw versus Treated, for Different Uses at Dakahlia Governorate, Egypt

Adel M. A. Elhdad
Basic Science Department, Madina Higher Institute of Engineering and Technology, Giza, Egypt.

WATER is one of the most important sources of economic development. In order to maintain living conditions, attention must be paid to water quality management, water pollution control and environmental protection. The pollution of the Nile river has increased recently due to population growth, economic development and related human activities. Egypt is among the 10 countries that will suffer from water scarcity by 2025 due to rapid population growth. This study aimed at the assessment of water quality according to drinking, agriculture and aquatic life purposes in El-Sinbellawein city and some of belonging villages, at Dakahlia governorate, Egypt. The water quality indices are an attempt to represent overall quality of water. Assessment of water quality for treatment plants under study according to drinking and aquatic life purposes was carried out using weighted arithmetic method of water quality index (WQI). Physico-chemical parameters of different water treatment plants at different locations were analyzed before and after water treatment and the obtained values were used for calculation of Water Quality Index (WQI). The values of WQI showed that the water is unsuitable in some treatment plants and excellent in another for drinking and aquatic life. Sodium adsorption ratio (SAR), percent sodium (Na %), residual sodium carbonate (RSC), Kelly Index (KI) and magnesium ratio (MR) were also calculated by using major anions and cations values to assess suitability of water for irrigation. The results indicated that all treatment plants under studying were classified from suitable to excellent for irrigation purposes. The study was extended also to include assess of water pollution by metals (Cd^{2+}, Cu^{2+}, Fe^{2+}, Mn^{2+}, Ni^{2+}, Pb^{2+}, and Zn^{2+}) via calculation of Metal index (MI) and pollution index (PI). The results indicate that there is no effect of metals in the case of water use for agricultural purposes, whereas for drinking and aquatic life, all measured metals except Zn^{2+} and Ni^{2+} show different degrees of contamination. The wastes should be treated before disposing and dumped to suitable sites, to protect the water quality from deterioration and maintain its quality.

Keywords: EL-Sinbellawein, Surface water, Water quality, Treatment, Agriculture, Aquatic life, Water pollution, Indexes, Heavy metals, MI, SAR.

Introduction

Nile River is the main water source for Egypt that meets nearly all demands for drinking water and irrigation [1]. There are heavy industries in Egypt along the Nile River, the most important of which are metal products, food, chemicals, and textiles industries [2]. The deterioration of water quality in the surface water bodies has become a serious worldwide problem due to anthropogenic activities like agricultural and industrial activities [3]. These anthropogenic activities cause pollution of surface water (rivers and lakes) with chemicals and excess nutrients [4]. It also greatly affects the quality of Nile water causing immediate and long-term health impacts on the users and on the aquatic fauna [5. One of most important of these pollutants is the trace metals, which are among the most persistent pollutants

---

Corresponding author e-mail: adelelhdad48@gmail.com; Tel.: 01002825005.
Received 1/1/2019, Accepted 15/1/2019
DOI:10.21608/ejchem.2019.6975.1582

that get accumulated in the biota and enters into the food chain cause serious risk on human health [6]. Most heavy metals accumulate in the tissues leading to destroying the life functions and poisoning of living organisms such as fish [7]. These pollutants affect by negativity on water systems, on fish populations, growth, survival, and reproduction [8]. Therefore, it is necessary to assess changes in water quality to identify the pollutants, categorize the water use and strategize the remedial measures to maintain the ecological health [3]. Researchers from the different parts of the world have developed a number of methodologies to assess the water quality. So they used many methods such as Water Quality Index of Central Pollution Control Board [9], eutrophication index (EI) [10] organic pollution index (OPI) [11], comprehensive pollution index (CPI) [12], Overall Index of Pollution [13] ... etc. Many researchers are interested in studying the water quality of the river or surface sea water, and the most important of these researchers are Abdel-Satar et al., [14], Alnagaawy et al., [4] and Emara [15]. The main objective of this study is to assess the water quality, water pollution with heavy metals, and the suitability of water in El-Sinbellawein city and some of villages, at Dakahlia governorate, Egypt, for drinking, irrigation, and aquatic life using WQI, PI,MI, %Na, SAR, RSC, MR, and KI.

Causes of Water pollution in Dakahlia.

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 [16]. Water contamination is the most dangerous hazards affecting Egypt. Pollution of water in Dakahlia Governorate has increased because of increases in population; industrial in the cities, agricultural activities in the villages and other new projects [17]. Domestic and industrial activities produce pollutants induce considerable changes in the physical and chemical properties of the Nile River and its canals. The heavy metals are the most important one of these pollutants [18]. Heavy metals have toxic effects on living organisms [19].

Materials and Methods

Studied area

This paper is concerned with the surface water in El-Sinbellawein city, some of its village, and Mit-Khamees village at El-mansoura, Dakahlia, Egypt. EL-Sinbellawein City is located in the south east of Dakahlia Governorate. It is bordered to the north by Mansoura, is bordered the south Diarb Najm in Eastern, Tami Amadeed from the eastern side, and Aja at the western side. Dakahlia Governorate is considered the base of the Nile Delta; It is located in the northeast of Nile Delta in Egypt between these coordinates 30.5 ° — 31.5 ° N, and 30 ° — 32 ° E as shown in Fig. 1. Dakahlia has a mild climate that tends to be warm in winter with some rain that increases on the coasts, and

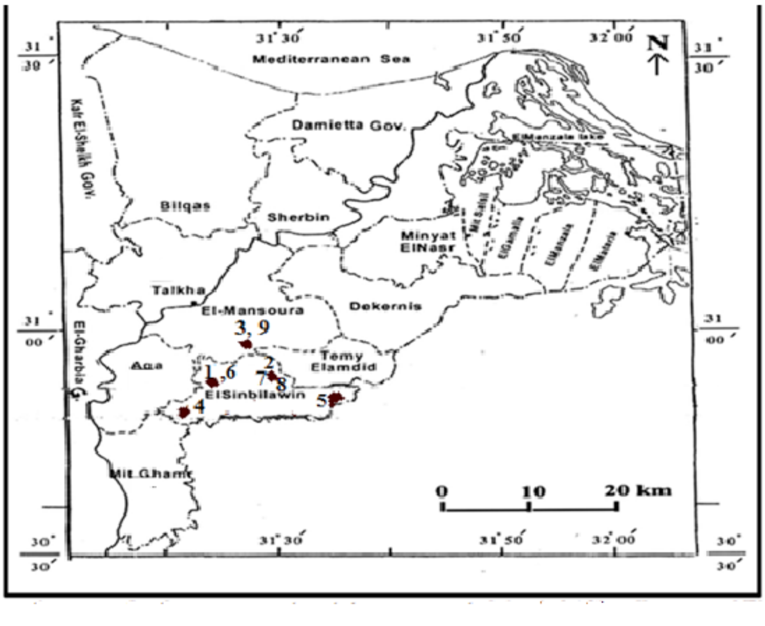

Fig. 1. Location map for the surface water treatment plants understudying in El-Sinbellawein and El-Mansoura city.

is hot in summer; where the average annual temperatures range from 14 — 28°C. Figure 1 shows sites of surface water treatment plants under study and the location of EL-Sinbellawein city at Dakahlia Governorate.

Collection and analysis of water samples

Eighteen surface water samples of different nine locations in El-Sinbellawein city, some of its villages, and Mit-Khamees village at EL Mansoura city were collected seasonally (2017–2018) by plastic bottles from input (raw water) in treatment plants 1, 2, 3, 4, and 5, and from output (treated water) in treatment plants 6, 7, 8, and 9, (Table 1).

Water temperature, electrical conductivity and pH value were measured in situ. The pH value was measured using a calibrated pH meter (Hanna instrument HI 8519 N). The electrical conductivity, total dissolved (TDS) and temperature were measured using Con. TDS. °C meter (Cyber Scan 200 CON). Then the water samples were kept in polyethylene bottles in ice box and transported to the laboratory for further analysis. The methods of analyses are discussed in the American Public Health Association (APHA, 2012). For analysis, all the instruments were calibrated appropriately according to the commercial grade calibration standard prior to the measurements. Total solids (TS) were measured by evaporating a known volume of well mixed sample at 105°C. TSS is direct obtained by subtracting TS from TDS. Dissolved oxygen (DO) was measured by using DO meter (HACH 40 D). Biochemical oxygen demand (BOD) was determined by using the 5 days method. Chemical oxygen demand (COD) was carried out using the potassium permanganate method. Turbidity was measured using turbidity meter (potable water analysis instrumentation (HACH). The determination of sodium (Na) and potassium (K) concentration was made by the flame photometer model 410, England. Chloride was measured using Mohr's method and sulfate by turbid metric method. Titrimetric methods were used for the determination of total hardness (TH), Calcium hardness (CaH) as $CaCO_3$, carbonate (CO_3^{2-}), and bicarbonate (HCO_3^-). Magnesium hardness (MgH) is direct obtained by subtracting TH from CaH. Also, Calcium and magnesium were determined by direct titration using EDTA solution. Concentrations of Fe^{2+}, Mn^{2+}, Ni^{2+}, Pb^{2+} , Cd^{2+}, Cu^{2+}, and Zn^{2+} were measured after digestion by conc. HNO_3 using an atomic absorption reader (Savanta AAS with GF 5000 Graphite Furnace). Concentrations of NO_2-N, NO_3-N, NH_4-N, and PO_4-P were determined using colorimetric techniques with the formation of reddish purple azo-dye, copper-hydrazine sulfate reduction, phenate, and ascorbic acid methods, respectively. Total phosphorus (TP) was measured as reactive phosphate after per sulfate digestion.

Estimation of Water quality index

Water quality index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water [21]. The suitability of water quality of surface water treatment plants under consideration has been evaluated by calculating WQI using the weighted arithmetic water quality index method, which classifies the water quality according to its degree of purity using the most commonly, measured water quality variables. The calculation method of WQI was developed by Brown et al. [22], and many scientists have been used this method widely [23]. The mathematical formula of this WQI method is given by:

TABLE 1. Locations of treatment plants under consideration.

S.L*	Type of water	Name of Location
1	Raw water (water before treatment)	Input of El-Sinbellawein water treatment plant
2	Raw water	Input of Brhamtosh water treatment plant 1
3	Raw water	Input of Mit Khamees water treatment plant
4	Raw water	Input of Barqin water treatment plant
5	Raw water	Input of El-waborat water treatment plant
6	Drinking water (water after treatment)	Output of El-Sinbellawein water treatment plant
7	Drinking water	Output of Brhamtosh water treatment plant 1
8	Drinking water	Output of Brhamtosh water treatment plant 2
9	Drinking water	Output of Mit Khamees water treatment plant

* S.L = Sampling location

WQI; And $Q_i = [(V_I - V_o)\ (S_i - V_o)]$, where Qi is the sub quality index of ith parameter (or Qi is the quality rating scale of each parameter), W= weight unit of each parameter, n = number of parameters, V_i = measured value of ith parameter, S_i = standard permissible value of ith parameter, V_o = ideal value of ith parameter in pure water, V_o = zero for all parameters except for pH = 7.0 and DO = 14.6 mg/L [24].

Calculation of unit weight (Wi)

Wi for various water quality parameters are inversely proportional to the recommended standards for the corresponding parameters Wi $1S_i$, or Wi = KS_i, where K is the proportionality constant of the "Weights" for various water quality characteristics:

$$K = \frac{1}{\sum_{i=1}^{n} \frac{1}{S_i}}$$

Estimation of SAR, Na %, KI, RSC, and MR

Sodium Adsorption Ratio (SAR) [25], Percent Sodium (Na %) [26], Kelly Index (KI) [27], Residual Sodium Carbonate (RSC) [28], and Magnesium Ratio (MR) [29] values were calculated by using the equations 1, 2. 3, 4, and 5, respectively:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \quad (1)$$

$$\%Na = \frac{Na^{+}\ X\ 100}{Na^{+} + Ca^{2+} + Mg^{2+} + K^{+}} \quad (2)$$

$$KI = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}} \quad (3)$$

$$RSC = (HCO_3^{-} + CO_3^{2-}) - (Ca^{2+} + Mg^{2+}) \quad (4)$$

$$MR = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} \quad (5)$$

Estimation of Metal quality index (MI)

The metal contamination of surface water under study has been determined using two different quality indices:

(i) *Pollution index (PI):* can be calculated by the following equation [30]:

$$PI = \frac{\sqrt{[(\frac{C_i}{S_i})^2_{max} + (\frac{C_i}{S_i})^2_{min}]}}{2}$$

Ci: the concentration of each metal; Si: metal level according to national water quality criteria.

(ii) **Metal index (MI)** is based on a total trend evaluation of the present status. The higher the concentration of a metal compared to its respective MAC value, the worse the quality of the water. MI value >1 is a threshold of warning [31]. According to Tamasi and Cini, [32], the MI is calculated by using the following formula:

(iii) $MI = \sum_{i=1}^{n} \frac{C_i}{(MAC)_i}$

Ci: the concentration of each element, MAC: maximum allowable concentration.

Results and Discussion

Assessment of physical and chemical parameters

The physicochemical parameters of the surface water quality data were statistically analyzed and the results were recorded in Table 2 in the form of range, mean and standard deviation.The temperature describes the natural condition of the surrounding mountains [33] and it is basically important for its effects on certain chemical and biological reactions taking place in water and aquatic organisms [34]. The temperature values are ranging from 13 to 27°C, where the maximum value was recorded in summer. Temperature is high positively correlated with pH, TS, TDS, EC, SO_4^{2-}, Cl^-, NO_3^-, NO_2^-, TP, Fe^{2+}, Mn^{2+}, Zn^{2+}, Cu^{2+}, Ni^{2+}, and Cd^{2+}. The values of pH ranged from 7.2 to 7.8, and indicate alkaline water in all treatment plants, with a significant difference between the sites (probability value or $p < 0.01$). There are high positive correlations between pH and DO, HCO_3^-, and CO_3^{2-} (r = 0.868, 0.98, 0.744, respectively). DO, BOD and COD were varied in the ranges of 2.6 – 5, 0 – 24 and 0 – 38 with significant local and seasonal variations (probability value or $p < 0.01$). There is no BOD in treatment plants 6, 7, 8, and 9, where the water samples were collected from outputs (treated water) of these treatment plants, so the microorganisms not present. Therefore, DO was recorded as the highest values in treatment plants 6, 7, 8, and 9 as a result of not present BOD; this result was found in good agreement with Fatoki et al.,[35]. The high values of COD were recorded at treatment plants 1, 2, 3, 4, and 5 during summer season, can be attributed to the discharge effluent from Industrial pollution [36]. The high values of COD and BOD might due to the decomposition process of organic matter by microbes consuming oxygen [33]. The basic nutrients show highly temporal significant differences ($p < 0.01$), and ranged between 0.00 – 0.1mg/L, 0.36 – 1.4mg/L, 0.00 –1.51 mg/L, 0.022 – 0.321mg/L, and 0.10 – 0.6 mg/L for nitrite, nitrate, ammonia, orthophosphate, and total phosphorus, respectively. The high values of nutrients were observed in treatment plants 1, 2, 3, 4, 5 and 8 due to the discharge effluents result from Fertilizers Company, industrial and domestic waste [33]. The increasing of ammonia content in river water is an indication of pollution [37]. The values of turbidity were ranged from 0.00 to 17 NTU in winter season and from 0.00 to 23 NTU in summer season. The lowest values of turbidity were recorded in treatment plants 6, 7, 8 and 9, where the water samples were collected from output of these treatment plants (or treated water). Turbidity is highly positively correlated with TSS ($r = 0.932$). TS, TDS and TSS were varied in the ranges of 242 – 351, 235 – 345 and 0.00 – 22 mg/L, respectively. ANOVA results show significant difference of solid content between different seasons and locations. Treatment plants 2, and 4 were recorded low values of TSS although the turbidity values for these treatment plants were observed to be high values, this means that TSS is not always followed by the turbidity linearly, since the measurement of turbidity based on the remaining amount of light after absorbed by the materials contained in the water (both suspended and dissolved), while TSS relies on the weight of the residue (after the water evaporated) from materials contained in the water as a suspension. Rainfall will result in decrease the TSS due to dilution which occurs in river water [37]. Electrical conductivity (E.C) was varied in the range 315 - 457S cm^{-1}. The increase in values of EC is mainly related to the effect of pollution, which increases the concentrations of Ca^{2+}, Mg^{2+}, HCO_3^- and Cl^- [38]. EC is positively correlated with Ca^{2+}, Mg^{2+}, Na^+, K^+, HCO_3^-, CO_3^{2-}, SO_4^{2-}, Cl^-, TDS, TS and TSS ($r = 0.961$, 0.965, 0.976, 0.978, 0.95, 0.671, 0.93, 0.977, 0.97, 0.99, and 0.99, respectively). CO_3^{2-} and HCO_3^- concentrations were varied between 0.130 – 1.12mg/L and 110 – 182mg/L with a highly spatial significant difference ($p < 0.01$). The values of chloride and sulfate ranged between 26 – 58mg/L and 32 – 80mg/L, respectively, with significant seasonal variations ($p < 0.01$), and a remarkable increase during the summer period; this result is in agreement with the result obtained by Goher et al.[16]. Chloride and sulfate have the same distribution pattern along surface water understudying, and are positively correlated with Ca^{2+} and Mg^{2+}. Calcium and Magnesium values were ranged between 32 to 44 and 10.29 and 16.17mg/L respectively. Calcium and magnesium values show highly seasonal variations ($p < 0.01$). The adsorption of calcium and magnesium onto clay minerals and deposition to the bottom will result in lowering the concentrations of calcium and magnesium [39]. Sodium and potassium were ranging from 16 to 23 and 6 to 10mg/L, respectively with a significant variation between sites and seasons ($p < 0.01$); this result is in agreement with the result obtained by Goher et al.[16]. The values of total hardness varied from 130 mg/L in treatment plant4 in winter to 166mg/L in treatment plant6 in summer. Calcium hardness ranged between 80 mg/L and 110mg/L, where the minimum value was recorded for treatment plants 2 and 8 in winter and the maximum value for treatment plants 1, 4, and 9. Also magnesium hardness was ranged between 42 mg/L for treatment plant4 and 66 mg/L for treatment plant 2 in winter and summer respectively. The concentrations of the heavy metals in treatment plants under consideration were in the ranges of (0.17 – 0.46mg/L), (0.01 – 0.1mg/L), (0.01 – 0.028mg/L), (0.0013 – 0.02mg/L), (0.01 – 0.02mg/L), (0.003 – 0.01mg/L), and (0.015 – 0.030mg/L) for Fe^{2+}, Mn^{2+}, Zn^{2+}, Cu^{2+}, Ni^{2+}, Cd^{2+},and Pb^{2+}, respectively. There is increasing in the heavy metal contents for treatment plants 1, 2, 3, 4, 8, and 9 due to different effluents of drains. Iron, manganese, lead, nickel and cadmium showed a highly temporal significant difference ($p< 0.01$) with increasing during summer season that agrees with the results obtained by Goher et al., [16] and Ibrahim et al., [40]. The increase of heavy metal concentrations in the water may be attributed to the liberation of heavy metals from the sediment to the overlying water under the effect of both temperature and organic matter decomposition due to the fermentation process [40].

TABLE 2. Mean, standard deviation and range of water parameters compared to guidelines used in WQI, PI and MI computations.

Parameters	Range	Mean.	SD	Drinking water [41,42]		Aquatic live (CCME,2007)
C°	13 — 27	26.22	0.833	40		8-28
Turb.	0 —23	10.577	10.16	1	10	
pH	7.2—7.8	7.2	0.132	8.5	6.5-8.5	6.5-9
BOD	0—24	11.444	11.01	5	5	5
COD	0—38	17.888	17.36	10	10	7
DO	2.6—5	3.4222	1.094	5	6	5.5
EC	315—457	412.33	43.1		2000	
TDS	235—345	322.55	22.08	500	1000	500
TSS	0—22	9.3333	9.1	500	500	+25
TS	242—351	331.22	16.24	-	-	-
T.H	130—166	156.55	7.468	500	500	
CaH	80—110	102.55	6.91			
MgH	42—66	54	8.231			
Ca^{2+}	32—44	40.833	2.90	75	75	
Mg^{2+}	10.29—16.1	13.258	2.002	50	50	
Na^+	16—23	20	1.87	200	200	
K^+	6—10	8.555	0.726	10	10	
HCO_3^-	110—182	156.55	17.85			
CO_3^{2-}	0.13—1.12	0.66	0.311			
SO_4^{2-}	32—80	51	12.59	200	250	
Cl^-	26—58	46.666	6.164	200	250	120
NH_3	0—1.51	0.6944	0.671	0.20	0.45	1.37
NO_3^-	0.1—1.4	0.8155	0.322	11	10	2.93
NO_2^-	0—0.1	0.0357	0.036	0.9	0.005	0.06
TP	0.1—0.5	0.3255	0.1		1	
$PO4_3^-$-P	0.024—0.08	0.044	0.024		1	
Fe^{2+}	0.17—0.46	0.307	0.144	0.3	0.3	0.3
Mn^{2+}	0.01—0.1	0.048	0.022	0.1	0.1	0.05
Cd^{2+}	0.003—0.01	0.004	0.0003	0.003	0.003	0.001
Pb^{2+}	0.015—0.03	0.021	0.006	0.01	0.01	0.007
Ni^{2+}	0.01—0.020	0.013	0.005	0.07	0.02	0.025
Zn^{2+}	0.01—0.028	0.018	0.005	0.5	3	0.05
Cu^{2+}	0.0013—0.02	0.004	0.002	2	2	0.004

CaH = Calcium Hardness, MgH = Magnesium Hardness

Suitability of water for drinking and aquatic life via WQI

Table 2 shows the water quality standards according World Health Organization [41] and Egyptian Ministry Health [42] used in the computation of the water quality index (WQI) for drinking of surface water under study. Protection of aquatic life was computed using guidelines of Canadian Council of Ministers of the Environment [43]. The classifications of WQI are represented in Table 3.

The selected parameters for the calculation of WQI according to drinking water include, pH, TDS, BOD, COD, DO, NH_3-N, NO_3^--N, TP, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+, and total hardiness. While, the selected variables for aquatic life included pH, TDS, DO, BOD, COD, Cl^-, NH_3-N, and NO_3^--N. The values are illustrated in Table 4 and Fig. 2.

According to drinking water quality standards

TABLE 3. Water quality rating as per weight arithmetic water quality index method

WQI value	Rating of water Quality	Grading
0 — 25	Excellent	A
26 — 50	Good	B
51— 75	Poor	C
76 — 100	Very poor	D
Above 100	Unsuitable for drinking purpose	E

TABLE 4. WQI and its categorization of surface water under study for drinking, and aquatic life utilizations.

Treatment plant	Drinking water		Aquatic life		Treatment plant	Drinking water		Aquatic life	
1	214.8	Unsuitable	106	Unfit	6	19.191	Excellent	46.3	Good
2	251.4	Unsuitable	132	Unfit	7	11.983	Excellent	20.2	Excellent
3	146.3	Unsuitable	104.8	Unfit	8	5.431	Excellent	15.7	Excellent
4	179.83	Unsuitable	110.2	Unfit	9	15.549	Excellent	11.4	Excellent
5	89.52	Very poor	76	Very poor					

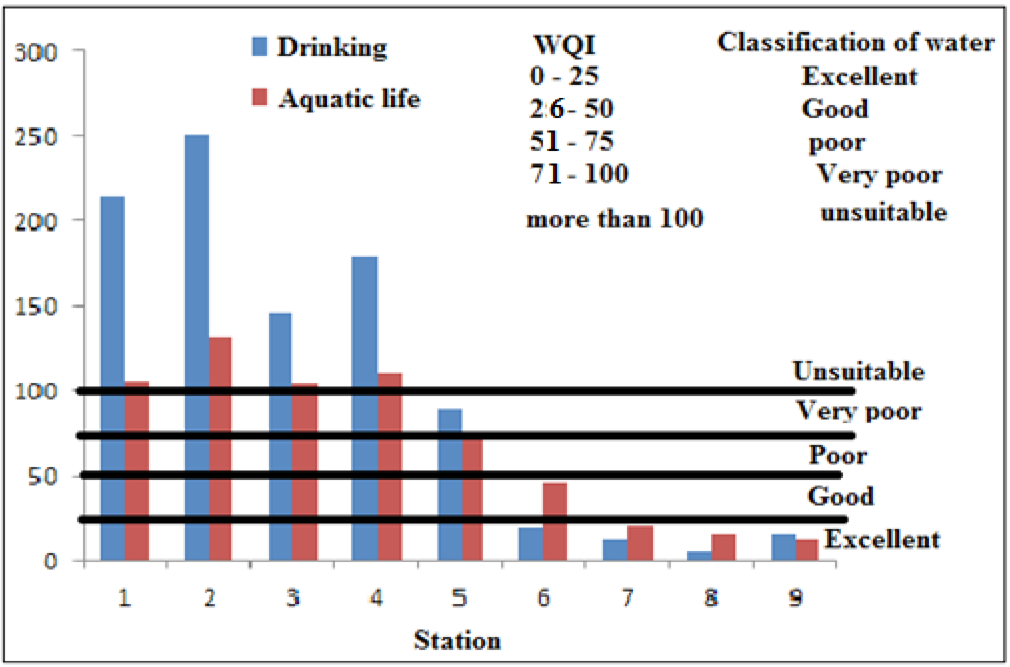

Fig. 2. WQI of surface water under studying for drinking and aquatic life utilizations.

and aquatic life guidelines, WQI values for water treatment plants under consideration were ranged from 5.431 to 251.4 and from 11.4 to 132, respectively (Table 4). Thus, Table 3 shows that the quality of surface water under study was classified according to drinking water quality standards and aquatic life guidelines as unsuitable, very poor and poor water for treatment plants 1, 2, 3,4 and 5, while it was classified from good to excellent water for treatment plants 6, 7, 8 and 9, this is because the samples were taken from the output (or after treatment) at these treatment plants.

Suitability of water for irrigation

Table 5 shows Classification of water based onNa (%), SAR, RSC, KI, and MR values.

To assess the suitability of water for irrigation, SAR, % Na, RSC, KI, and MR values were calculated by using major anion and cation values and according to equations 1, 2, 3, 4, and 5. As shown in Tables 5, 6, %Na values for treatment plants 1, 2, 3, 7, 8, and 9 lower than 20, and were considered as excellent for irrigation in summer season, while the remaining treatment plants were good for irrigation (%Na > 20). But in winter season, all treatment plants were considered as good category for irrigation except treatment plant 7, which was considered excellent. According to KI, SAR, MR, and RSC values, all water treatment plants under consideration were considered as suitable and good for irrigation in winter and summer seasons.

Assessment of the metal pollution according to pollution Index

PI is categorized into 5 classes (Table 7).

In this research, seven metals were selected to evaluate the metal contamination of surface water, according to the pollution index, and depending on individual metal calculations. These metals are, Fe^{2+}, Mn^{2+}, Ni^{2+}, Pb^{2+}, Cd^{2+}, Cu^{2+}, and Zn^{2+}. Table 8 shows the values of PI for drinking,

TABLE 5. Classification of water based on Na (%), SAR, RSC, KI, and MR values.

Na (%)	Water quality	SAR	Water quality	RSC	Water quality
<20	Excellent	<10	Excellent	<1.25	Good
20—40	Good	10—18	Good	1.25 —2.5	Medium
40—60	permissible	18—26	Doubtful	>2.5	Unsuitable
60—80	Doubtful	>26	Unsuitable		
>80	Unsuitable	MR	Water quality		
KI	Water quality	< 50%	suitable		
<1	suitable	>50%	unsuitable		
>1	unsuitable				

TABLE 6. %Na, KI, SAR, MR, and RSC of surface water treatment plants under study in winter and summer season

S.L	Summer					Winter				
	%Na	SAR	RSC	MR	KI	%Na	SAR	RSC	MR	KI
1	18.633	0.6637	-0.207	0.317	0.243	22.411	0.9425	-0.306	0.3525	0.3127
2	17.849	0.5824	-0.726	0.4178	0.2291	20.530	0.6587	-0.71	0.4336	0.277
3	18.084	0.7680	-0.24	0.3637	0.2351	23.841	0.808	-0.169	0.3712	0.3417
4	20.462	0.6683	-0.376	0.280	0.270	23.552	0.8741	-0.146	0.3274	0.332
5	21.908	0.719	-0.099	0.3424	0.2977	24.86	0.8431	-0.05	0.2899	0.355
6	20.913	0.6389	-0.875	0.3539	0.247	20.358	0.6716	-0.885	0.419	0.2729
7	17.008	0.550	-1.13	0.4231	0.218	17.944	0.5894	-1.34	0.428	0.2346
8	19.403	0.6451	-0.605	0.348	0.2657	22.539	0.7375	-0.872	0.4252	0.3124
9	19.651	0.6769	-0.826	0.3333	0.2635	21.728	0.7387	-0.984	0.346	0.2985

irrigation, and aquatic life at all treatment plants under consideration.

For irrigation and drinking utilizations all measured metals exhibit no effect at all treatment plants understudying, except stations 8, and 9 which slightly effected by Fe^{2+}. For aquatic life and drinking purposes, Pb^{2+} effects ranged from slight to moderate and strong at all treatment plants except station 7. Mn^{2+} and Cu^{2+} were exhibits slightly effect at treatment plants 3, and 1 with respect to aquatic life. Slightly and moderately effects were observed of Cd^{2+} in aquatic life at all treatment plants. Zn^{2+} and Ni^{2+} show no effect on

TABLE 7. Categories of Water Pollution Index (PI).

Class	PI value	Class
1	< 1	No effect
2	1—2	Slightly affected
3	2—3	Moderately affected
4	3—5	Strongly affected
5	> 5	Seriously affected

TABLE 8. Pollution Index (PI) of the measured metals in surface water under study according to guideline levels of drinking, irrigation and aquatic life water

Pollution Index (PI) For drinking

S.L	Fe^{2+}	Mn^{2+}	Zn^{2+}	Cu^{2+}	Ni^{2+}	Cd^{2+}	Pb^{2+}
1	0.38	0.13	0.0033	0.0020155	0.5273	0.7453	1.1715
2	0.4576	0.32	0.0030	0.0017677	0.47169	0.9718	1.2041
3	0.3778	0.583	0.0032	0.00134	0.53677	0.8333	1.1715
4	0.8348	0.43	0.0044	0.00079	0.6403	0.8333	1.4705
5	0.8197	0.36	0.00388	0.001677	0.49307	0.5270	1.4159
6	0.7168	0.25	0.00436	0.00079	0.6250	0.8498	1.5239
7	0.9245	0.18	0.00447	0.00134	0.5202	0.3726	0.1118
8	1.210	0.32	0.000032	0.00145	0.5350	0.6871	1.8117
9	1.1864	0.25	0.0060	0.00127	0.4716	0.6009	2.1260

Pollution Index (PI) for Irrigation

S.L	Fe^{2+}	Mn^{2+}	Zn^{2+}	Cu^{2+}	Ni^{2+}	Cd^{2+}	Pb^{2+}
1	0.0228	0.065	0.00496	0.02015	0.052737	0.22360	0.002339
2	0.02745	0.16	0.0045	0.01767	0.047169	0.29095	0.002408
3	0.02262	0.2915	0.0048	0.0134	0.053677	0.24941	0.002339
4	0.04998	0.215	0.0066	0.0079	0.06403	0.2494	0.002941
5	0.04908	0.18	0.00582	0.01677	0.04930	0.15778	0.002831
6	0.042922	0.1250	0.00654	0.0079	0.06250	0.25443	0.003047
7	0.05535	0.09	0.00670	0.0134	0.05202	0.11155	0.000236
8	0.072455	0.16	0.000045	0.0145	0.05350	0.20571	0.003623
9	0.0710	0.125	0.009	0.0127	0.04716	0.17991	0.004252

Pollution Index (PI) for Aquatic

S.L	Fe^{2+}	Mn^{2+}	Zn^{2+}	Cu^{2+}	Ni^{2+}	Cd^{2+}	Pb^{2+}
1	0.7891	0.26	0.1984	1.00778	0.4219	2.23606	1.67238
2	0.9157	0.64	0.18	0.88	0.377352	2.29095	1.72172
3	0.8776	1.166	0.192	0.67	0.42941	2.4941	1.67362
4	1.700	0.86	0.264	0.395	0.51224	2.494	2.102815
5	1.630	0.72	0.2328	0.8385	0.3944	1.577	2.024165
6	1.456	0.5	0.2616	0.395	0.5000	2.5443	2.178605
7	1.9245	0.36	0.268	0.67	0.41616	1.1155	0.16874
8	2.650	0.64	0.17	0.725	0.428	2.0571	2.590445
9	2.3724	0.500	0.36	0.635	0.37728	1.7991	3.000

drinking and aquatic life at all treatment plants.

Assessment the degree of metal pollution via metal index

Also, a metal index was used to estimate the degree of metal contamination of surface water under consideration when used for different purposes. According to metal index values (Table 9), all selected treatment plants under study are seriously threatened with metal pollution for drinking, and aquatic uses (MI >1) in winter and summer seasons. On the other hand, no effect on using water for irrigation purposes at all treatment plants in winter and summer seasons (MI < 1), except treatment plant 3 in summer season which suffer from slightly effect (MI > 1).

Conclusion

Surface water is considered the most important source of drinking, irrigation and aquatic life in all cities and villages of Dakahlia governorate. But it exposed to deterioration in its quality due to different wastes that discharge into the water. The aim of this research is to assess the state of surface water before and after treatment, and determine the quality and suitability of the water for drinking, agriculture and aquatic life purposes. The results showed that the concentrations of turbidity, BOD, COD, ammonia, and nitrite are greater than the recommended levels for drinking water at treatment plants 1, 2, 3, 4, and 5. The concentrations of cadmium and lead at all treatment plants are greater than the quality standards for drinking water**.** Also, iron content in treatment plants 4,5,7,8 and 9 is greater than the maximum permissible limit. The WQI values show that the water quality of treatment plants 1, 2, 3, 4, and 5 is classified as unsuitable for drinking and aquatic life utilizations, while the water quality of treatment plants 6, 7, 8 and 9 is classified as excellent. SAR, % Na, RSC, KI, and MR values showed that all treatment plants under study were classified from suitable to excellent for irrigation purposes. The values of Metal index (MI) and pollution index (PI) show that all measured metals except Zn^{2+} and Ni^{2+}, exhibit different contamination grades for drinking and aquatic life in the water of treatment plants under study.

TABLE 9. Metal index (MI) in surface water under consideration according to guideline levels of drinking, irrigation and aquatic life water utilizations in winter and summer seasons.

S.L	Drinking		Irrigation		Aquatic life	
	Winter	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**
1	4.0736	4.09779	0.4071	0.6475	7.391	9.539
2	4.4717	4.3541	0.6116	0.8322	8.0680	10.8397
3	4.62266	4.6398	0.7495	1.0146	8.4695	10.9614
4	5.1401	6.5408	0.8204	0.8403	9.4319	11.2385
5	5.2753	4.6235	0.6803	0.5562	10.2209	7.6833
6	5.957	4.8071	0.8531	0.439	11.6090	7.0738
7	3.9736	5.85916	0.3446	0.567	7.038	10.42414
8	5.7891	6.7921	0.5336	0.8366	9.1157	12.21
9	6.4748	6.5451	0.6341	0.6134	10.5766	11.2880

Acknowledgment

It is honor to acknowledge support efforts given by Chemistry Department, Faculty of Science, Cairo University and Madina Higher Institute of Engineering and Technology in cooperation with National Authority for Potable Water and Wastewater, especially the central laboratories.

References

1.Toufeek, M.A., Korium, M.A., Physico-chemical characteristics of water quality in Lake Nasser water, *Global Journal of Environmental Research* **3**(3), 141- 148 (2009).

2. Hamza, A., Gallup, J., Assessment of environmental

pollution in Egypt: Case Study of Alexandria Metropolitan. World Health Organization (WHO) 56-61 (1982).

3. Mishra, S., Sharma, M.P., Kumar A., X. Assessment of Surface Water Quality in Surha Lake using Pollution Index, India., *Journal of Materials and Environmental Science* **7** (Y), 713-719 (2016).

4. Alnagaawy, A.M., Sherif, M.H., Assy, M.G., Shehata, A.S., X. Impact of industrial pollutants on some water quality parameters of Edku, Mariout lakes and the Nile River. *International Journal of Environment* **7**(1), 1-15 (2018).

5. Authman, M.M.N., Abbas, H.H., Abbas, W.T., Assessment of metal status in drainage canal water and their bioaccumulation in Oreochromisniloticus fish in relation to human health Environmental Monitoring and Assessment. *Environmental Monitoring and Assessment* **185** (1), 891-907 (2013).

6. Barnwal, P., Mishra, S., Singhal, S.K., Assessment of Water Quality in Surha Lake Based on Physiochemical Parameters, India. *Journal of Integrated Science and Technology* **3**, 22-27 (2015).

7. Authman, M.M.N., Zaki, M. S, Khallaf, E. A., Abbas, H.H., Use of fish as bio-indicator of the effects of heavy metals pollution. *Aquaculture Research & Development* **6**(4), 1-13 (2015).

8. Vilbur, H.C., Chou, H., Pohi, Y., Stevens, P., Alfred, N., Roney, M., Fay, L., Tylenda, C., Agency for toxic substances and disease registry's list of hazardous substances.Latent effects carcino-neurotoxicology, and its drevature in humans and animals, *Journal of Toxicology and Environmental Health* **15**, 602-644 (1999).

9. Bai, R.V., Bouwmeester, R., Mohan, S., Water quality index and importance of water quality parameters. *Air, Soil, and Water Research* **2**, 51–9 (2009).

10. Liu, S., Lou, S., Kuang, C., Huang, W., Chen, W., Zhang, J., Zhong, G., Assessment of Surface Water Quality in Surha Lake using Pollution Index, India.*Marine Pollution Bulletin Journal* **62**, 2220–2229 (2011).

11. Quan, W.M, Shen, X.Q, Han, J.D, Chen, Y.Q., Analysis and assessment on eutrophication status and developing trend in Changjiang estuary and adjacent East China Sea. Marine Environmental Research, **24**, 13–16 (2005).

12. You, Z.J., Lu, J.X., Liu, Y.Y., The Improvement of Calculation Formula of Comprehensive Pollution Index. *Nei Environmental Science* **21**, 101-102 (2009).

13. Sargaonkar A and Deshpande V Development of an overall index of pollution for surface water based on a general classification scheme in Indian context. *Environ. Monit. Assess.* **89,** 43-67 (2003).

14. Abdel-Satar, A. M., Ali, M. H., E.Goher, M., Indices of water quality and metal pollution of Nile River, Egypt. *The Egyptian Journal of Aquatic Research,* **43** (1), 21-29 (2017).

15. Emara, M.M., Farid, N.A., El-Sabagh, E. A., Physico-chemical Study of surface Seawater in The Northwestern Gulf of Suez, *Egypt. J. Chem.* **56** (5, 6), 345-365 (2013).

16. Goher, M.E., Hassan, A.M., Abdel-Moniem, I.A., Fahmy, A.H., El-sayed, S.M., Evaluation of surface water quality and heavy metal indices of Ismailia Canal, Nile River, Egypt. *Egyptian Journal of Aquatic Research* **40**, 225-233 (2014).

17. Hagras, A.E., El-Gammal, M.I., Abdrabouh, A.E., El-Bahnasy H.T., Environmental Impact Assessment of Heavy Metals on African Catfish (Clariasgariepinus) of some Drains in Dakahlia Governorate, Egypt. *IOSR Journal of Environmental Science, to Xicology and Food Technology (IOSR-JESTFT)* **11**(1) Ver. II, 39-51 (2017).

18. El-Sayed, S.M.M., Physicochemical studies on the impact of pollution up on the River Nile branches, Egypt (*M.Sc. Thesis*). Faculty of Science, Benha University, Egypt, P. 248 (2011).

19. Khalil, M.K.H, Radwan, A.M., El-Moselhy, K. H.M., Distribution of phosphorus fractions and some of heavy metals in surface sediments of Burullus lagoon and adjacent Mediterranean Sea. *Egyptian Journal of Aquatic Research,* **33** (1), 277–289 (2007).

20. American Public Health Association (APHA)/ AWWA, Standard Methods for the examination of water, and waste water, 22nd edition, 1360 pp— ISBN 978—087553—013—0, American Public Health Association, WPCF Washington DC, USA (2012).

21. American Public Health Association (APHA)/ AWWA, Standard Methods for the examination of water, and waste water, 22nd edition, 1360 pp— ISBN 978—087553—013—0, American Public

Health Association, WPCF Washington DC, USA (2012).

22. Brown, R.M, McCleiland, N.J., Deininger, R.A., Connor, M.F.A., Water Quality Index – Crossing the Psychological Barrier. In: Jenkis, S.H. (Ed.), *Proceedings in International Conference on Water Pollution Research Jerusalem* **6**, 787–797 (1972).

23. Tyagi1, S., Sharma, B., Singh, P., Dobhal, R., Water Quality Assessment in Terms of water quality index. *American Journal of Water Resources*, **1**(3), 34–38 (2013).

24. Tripaty, J.K., Sahu, K.C., Seasonal hydrochemistry of groundwater in the Barrier Spit system of the Chilika Lagoon, India. *Journal of Environmental Hydrology* **13**, 1–9 (2005).

25. Richard, L.A., Diagnosis and improvement of saline and alkaline soils. In: *Agricultural Handbook,* vol. 60, p 160, USDA, Washington, DC (1954).

26. Wilcox, L.V., Classification and use of irrigation waters.USDA, circular 969, Washington, DC, USA (1955).

27. Kelly, W.P., Permissible composition and concentration of irrigated waters. In: Proceedings of the A.S.C.F 607 (1940).

28. Eaton, F.M., Significance of carbonates in irrigated waters, Soil Science, 69, 127–128. Doi: 10.1097/00010694-195002000-00004 (1950).

29. Szabolcs, I., Darab C., The influence of irrigation water of high sodium carbonate content on soils. In I. Szabolics (Ed.), *Proc 8th International Congress Soil Science Sodics Soils, Res Inst Soil Sci Agric Chem Hungarian Acad Sci, ISSS Trans* II, 802–812 (1964).

30. Caerio, S., Costa, M.H., Ramos, T.B., Fernandes, F., Silveira, N., Coimbra, A., Mederios, G., Painho, M., Assessing heavy metal contamination in Sado Estuary sediment: an index analysis approach. *Ecolog. Indicators* **5**, 151–169 (2005).

31. Bakan, G., Boke Ozkoc, H., Tulek, S., Cuce, H., Integrated environmental quality assessment of Kızılırmak River and its coastal environment. *Turk. J. Fisheries Aquat. Sci.* 10, 453–462 (2010).

32. Tamasi, G., Cini, R., Heavy metals in drinking waters from Mount Amiata. Possible risks from arsenic for public health in the province of Siena. *Sci.Total Environ.* **327**, 41–51 (2004).

33. Effendi, H., Ramanto Wardianto, Y., Water quality status of cimbulawung River, Banten Province, based on Pollution index and NSF — WQI. *Procedia Environmental Sciences*, **24**, 228 — 237 (2015).

34. Saksena, D. N., Garg, R.K., Rao, R.J., Water quality and pollution status of Chambal River in National Chambal Sanctuary, Madhya Pradesh. *Journal of Environmental Biology* **29**(5), 701-10 (2008).

35. Fatoki, O.S., Muyima, N.Y.O., Lujiza, N., Situation analysis of water quality in Umtata River catchment. *Water SA* **27**(4), 467-74 (2001).

36. Fatoki, O.S., Muyima, N.Y.O., Lujiza, N., Situation analysis of water quality in Umtata River catchment. *Water SA* **27**(4), 467-74 (2001).

37. Amneera, W.A., Najib, N.W.A.Z., Yusof, S.R.M., Ragunathan, S., Water quality index of Perlis River, Malaysia. *International Journal on Civil and Environmental Engineering* **13** (2), 1-6 (2013).

38. Zayed, M.A., ElHdad, A.M.A., Assessment of Ground Water Pollution with Heavy metals based on Pollution Index and Investigation of GroundWater Quality using Water Quality Index in Western Nile Delta, Egypt. *Internal Journal of Scientific Engineering and Research (IJSER)* **5**(9), 24-35 (2017).

39. El-Bourie, M.M.Y., Evaluation of organic pollutants in Rosetta branch water- River Nile (M.SC.Thesis).Fac., of Sci., Tanta Univ., Egypt. (2008).

40. Ibrahim, A.T.A., Omar, H.M., Seasonal variation of heavy metals accumulation in muscles of the African Catfish Clariasgariepinus, River Nile water and sediments at Assiut Governorate, Egypt. *J. Biol. Earth Sci.* **3** (2), 236–248 (2013).

41. Guidelines for Drinking Water Quality, Fourth ed. World Health Organization (WHO), Geneva, Switzerland, V.1, 541 (2011).

42. Egyptian drinking water quality standards, Ministry of Health, Population Decision number (458) (2007).

43. CCME (Canadian Council of Ministers of the Environment), 2007.For the protection of aquatic life 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg (1999).

تقييم نوعية المياه السطحيه الخام مقابل المياه المعالجه للاستخدامات المختلفه فى محافظة الدقهليه بمصر

عادل محمد عبده الحداد
معهد المدينه العالى للهندسه والتكنولوجيا - الجيزة - مصر.

تعتبر المياه واحدة من أهم مصادر التنمية الاقتصادية. ونظرا لازدياد معدل تلوث نهر النيل في الآونة الأخيرة بسبب النمو السكاني والتنمية الاقتصادية والأنشطة البشرية ذات الصلة كان هذا البحث الذى يهدف الى دراسة تقييم جودة المياه السطحية الخام مقابل المعالجة، لاستخدامات الشرب والزراعة والأحياء المائية وتمت الدراسه على المياه السطحيه قبل وبعد المعالجه فى بعض محطات قرى ومدن محافظة الدقهلية. حيث اجريت العديد من التحاليل الفيزيائيه والكيميائيه لمياه تلك المحطات واستخدمت القيم التي تم الحصول عليها لحساب مؤشر جودة المياه (WQI). و أظهرت النتائج أن الماء غير مناسب في بعض المحطات وممتاز في الآخر بالنسبه للشرب والحياة المائية. تم كذلك حساب نسبة الصوديوم (Na٪) ونسبة امتصاص الصوديوم (SAR) وكربونات الصوديوم المتبقية (RSC) ونسبة المغنيسيوم (MR) وKelly Index (KI) باستخدام قيم بعض الأنيونات والكاتيونات لتقييم ملاءمة المياه للري. وأشارت النتائج إلى أن جميع محطات المعالجة تحت الدراسة تتنوع فى تصنيفها من مقبوله أو مناسبة إلى ممتازة لأغراض الري. كما تم التوسع فى البحث ليشمل تقييم تلوث المياه بالمعادن فتم قياس تركيزات الكادميوم والنحاس والزنك والحديد والمنجنيز والنيكل والرصاص واستخدمنا الفيم فى قياس مؤشرات التلوث المعدنى للمياه MI, PIوبينت النتائج أنه لا يوجد تأثير للمعادن في حالة استخدام المياه للأغراض الزراعية والشرب والأحياء المائية باستثناء الزنك والنيكل اللذان أظهرا درجات مختلفة من التلوث للمياه فى بعض المحطات. وفى النهايه أوصيت فى هذا البحث بأنه يجب معالجة النفايات قبل التخلص منها ثم إلقائها في مواقع مناسبة، وذلك لحماية جودة المياه من التدهور والحفاظ على جودتها. كما يجب إيلاء الاهتمام لإدارة نوعية المياه، وحماية البيئة ومراقبة جودة المياه للحفاظ على دوام عدم تعرضها للتلوث.