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The effect of industrial and sewage effluent on water quality of the White Nile River at south of Khartoum City, Sudan

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Abstract
The pollution of River Nile and its tributaries is greatly obsessing the concerned authorities and stakeholders. To assess the effect of sewage effluent on the White Nile River at southern Khartoum City, a total of 180 water samples were sampled from different sites: the main treatment pools, the effluent carrier canal, discharge joint with the river, before and after discharge joint, and analyzed for routine physicochemical parameters. The mean values obtained were: T (35.0 C^0), EC (1859.7 dS/m), TSS (480.3mg/l), SOM (8.99 mg/l), TDS (1078.61 mg/l), DO (0.46 O_2/l), TA (580.0 mg/l), TH (174.11 mg/l), Ca^{++} (37.1 mg/l), Mg^{++} (22.2 mg/l), Na^{+} (249.4 mg/l), K^{+} (29.9 mg/l), NO_3^{-} (48.5 mg/l), NH_3^{-} (24.83 mg/l), Cl^{-} (353.57 mg/l), SO_4^{2-} (16.6 mg/l), PO_4^{3-} (10.15 mg/l), S^{2-} (37.73 mg/l), SOM (7.58 mg/l), BOD (320.70 mg/l) and COD (569.40 mg/l). These mean values found to be significantly different comparing to the control, indicating the low performance of the treatment plant. It may be concluded that the effluent of Industrial Military Factory and Soba Wastewater Treatment Plant is negatively impacts the water quality of the White Nile River and poses hazard to the aquatic life and the public health at the surrounding environment.

Key words: *sewage, effluent, treatment, plant, wastewater, physicochemical.*

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I. Introduction:

Pollution of water is most commonly associated with the discharge of effluents from sewers or sewage treatment plants, from drains and factories to the water body of rivers, and from seas or marines. (Rashed (2014) stated that the aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both human and animals. Recently, the increasing use of waste chemicals and agricultural drainage systems represents the most dangerous chemical pollution. One of the main environmental problems in Sudan is the problem of water pollution. This is obviously observed in Khartoum City more than in any other city along the rivers, The increase of urbanization and industrialization in Khartoum City resulted in a rapid increase of municipal waste water (sewage and industrial effluents), which in turn has intensified the environmental pollution. Huge amounts of sewage treatment plant and industrial wastewater has been releasing into the White Nile. Effluents discharged into the White Nile may affect water quality. Dirar (1986) indicated that a particular point source of pollution of the White Nile at Khartoum City is the continuously flowing stream coming from city sewage treatment plant at Soba and the surrounding areas.

The quality of drinking water in the Sudan has currently received some attention from environmentalists and water scientists. Recent studies in Khartoum City have demonstrated clearly the close association of biological and chemical contamination of drinking water (Abdellah, *et al*, 2014). The River Nile and its tributaries face many problems, first: the discharge of untreated wastewater and sewage from some industries in the River Nile, second: wastewater from refinery stations (containing polymers and other chemicals), third: agricultural chemicals waste. Most of the water treatment stations in Khartoum City are old and designed to receive about 8000 ppm of suspended matter particles. In the1980's, especially during and after the drought & desertification period, the amount of mud and suspended solids increased in flood period, amounting to about 21,000 ppm and the turbidity level reached about 6850 NTU (Abdellah, *et al*, 2014 ; Abdel-Magid *et al.*, 2014)). The industrial facilities discharge a wide variety of liquids in the treatment plant under the study. This has led to a decrease in the efficiency of waste treatment disposal and consequently deteriorated the

surrounding environment. According to WHO (2004) wastewater obtained from industries is generally much more polluted than the domestic or even commercial wastewater. Therefore, this study is conducted to evaluate the efficiency of Soba Treatment Plant and its relationship to the degradation associated with the White Nile River water quality and the surrounding environment.

II. Materials And Methods

Water samples collection and water analysis

A total of 180 water samples were collected from different locations: L_1 samples taken from the main pond of Suba Treatment Plant, L_2 samples taken from the main drain canal that carries sewage from both military industry and Suba Treatment Plant. L_3 samples taken from the discharge point zone (the joint of canal with the river, L_4 samples taken from upstream the river, and L_5 samples taken from downstream. L_0 samples taken from the lake reservoir of Jebel Awliya Dam as a control sample which located south of the discharge zone upstream the river (Figure 1 and figure 2).

The analyses were carried out according to the standard Methods for the Examination of Water & Wastewater (APHA, 1998) and Richards (1954). All of the reagents used during water analyses were of analytical grade.

Physical parameters of water samples

A pH-meter device model sensios3 was used for measuring **pH**, using spectrophotometer model (HACH) 4000. Electrical conductivity **(EC)** was determined by using Electrical Conductivity Meter. A photometric method was used for the determination of total suspended solids **(TSS)**. Suspended organic matter **(SOM)** in sediment was calculated as w/w% (APHA, 1995). Total Dissolved Solids **(TDS)** was determined by using conductivity-meter model session5 (HACH). Dissolved oxygen **(DO)** was measured using Indigo Carmine Method 8166 (AccuVac® Ampuls) for water and waste water and test results are measured at 535 nm using spectrophotometer model (HACH) 4000 DR.

Chemical parameters

Total Alkalinity **(TA)** as $CaCo_3$ was measured by a titrimetric method. EDTA titrimetric method was used for the estimation of total hardness **(TH)**. Result recorded as mg/l total hardness and calculated as calcium carbonate. EDTA titrimetric method was used for the estimation of calcium **(Ca^{++})**. Magnesium **(Mg^{++})** was estimated as the difference between hardness and calcium as $CaCO_3$. Flame photometric Method was applied to measure sodium **$(Na)^{+}$** and potassium **$(K)^{2+}$**. Nitrate **$(NO_3)^{-}$** determined by using cadmium reduction method in water and waste water. Spectrophotometer model (HACH) 4000 sample cell was used to determine nitrate. Nitrite **$(NO_2)^{-}$** was determined by using diazotization methods and spectrophotometer model (HACH) 4000 DR was used to determine nitrite. Wavelengths set were 589.0 nm for sodium and 766.5 nm for potassium in the presence of air acetylene flame. Ammonia **$(NH_3)^{+}$** determined according to nessler method. The spectrophotometer model (HACH) 4000 DR - Sample cell was used to determine of ammonia. Argentometric method in which the water sample is titrated against standard $AgNO_3$ titrant was used for the estimation of chloride **(Cl^{-})**. Sulfate **$(SO_4)^{2-}$** was measured using SulfaVer4 methods (powder pillows) for drinking water. Spectrophotometer model (HACH) 4000 DR Was used to determine sulfate. Phosphate **$(PO_4)^{3+}$**measured by using orthophophsphate phosver3 (Ascorbic acid), powder pillows was used. A **S^{2-}**was measured by Spectrophotometer Hach DR/5000. Biochemical oxygen **(BOD)** demand was determined by Azid (Alsterberg) method. Chemical oxygen demand **(COD)** determined by open reflux method.

III. Results And Discussion

Physical analysis of water samples

Physical analysis of water samples was summarizes in table 1. Results revealed that the mean water samples' temperature **(T)** in location of L_1 (33.4), L_2 (35.0), L_3 (34.9), L_4 (30.2) and L_5 (30.8) was higher than in control sample L_0 (29.0). The highest T mean value (35.0) was observed in water samples taken from the canal (L_2). The high elevation of temperature of the effluent discharged from the military industry and the treatment plant may cause some localized increase in river water temperature, but no drastic changes were observed. In addition, temperature affects the bacterial activities, which responsible for the decomposition of organic matter needed for nutrient recycling, as well as increasing solubility and liberation of dissolved gases e.g., O_2, CO_2 , NH_3, H_2S, and hydrolysis of HCO_3^- and CO_3^2 and appearance of hydroxyl ions with a companying of increase pH value.

As shown in table (1), the **pH** mean value of the control water sample (L_0) was 7.77, whereas the other pH mean value of polluted water samples (L_1, L_2, L_3, L_4, L_5) were found to be higher than the control sample. Generally, the pH mean value of waste water samples tend to be slightly alkaline. The highest pH mean value (7.95) was observed in water samples taken from the river discharge zone (L_4, L_5). The increase of pH level of

the effluent may be attributed to the high concentrations of carbonate and bicarbonate ions resulting from evaporation of wastewater during the course of the treatment. Ayers and Westcot (1994) indicated a pH range of 6.5 – 8.0 as normal for utilization of wastewater for irrigation. However, the Sudanese Standards and Metrology Organization (SSMO, 2006) adopted a pH range of 6 - 10 for disposing wastewater into rivers and recreational beaches, it is noteworthy that the SSMO (2002) and WHO (1993) adopted the range for pH level in drinking water is to be 6.5-8.5. According to the SSMO regulations that set for pH for liquid waste after final treatment, the pH values of all water samples found to be fall within the adopted range. Similar result of pH level (5.32-7.56) has been reported by Abdel-Magid *et al.* (2014) in a registration of routine chemical analysis of sewage effluent in Wadafea Treatment Plant at Khartoum North, Sudan. As well, a similar result reported by Al-Turki (2010) as he found pH values of the influent and the effluent of the Tertiary Wastewater Treatment Plant at Buraidah City, Saudi Arabia, ranging between 7.32 and 7.91. Colmenarejoa *et al*. (2006) attributed the increase of pH values of effluent to the dissolved of CO_2 concentration through a reduction in the concentration of organic matter due to oxidation during the treatment. The mean values of salinity, as **EC** µS/cm, of wastewater found to be very high in samples L_1 (1667.2 µS/cm, **TDS**=1078.61 mg/l) and sample L_2 (1859.7 µS/cm, TDS=937.71 mg/l) comparing to the control L_0 (220.0 µS/cm, TDS=141.71 mg/l), to less extent, mean value of EC regarding sample L_3 was found to be 643.8 µS/cm (TDS=403.31 mg/l), while the EC mean values of samples L_4 and L_5 found to be 158.3 µS/cm (TDS=99.5 mg/l) and 163.1 µS/cm (TDS=105.58 mg/l), respectively. The EC mean value of sewage effluent in the drain canal (L_1 and L_2), as shown in table 1, was found to be higher than that of samples taken from up and downstream (L_4 and L_5), this may be attributed to the decline of concentration of the effluent salts by the river water. Stoddard *et al*. (1999) stated that the municipal, agricultural, and industrial discharges can contribute ions to receiving waters or can contain substances that are poor conductors (organic compounds) changing the conductivity of the receiving waters. The high EC mean value indicated that sewage effluent from Treatment Plant at Soba is well above the allowable recommended standards for land disposal and irrigation reuse as set by the SSMO (2006). Similarly, Abdel-Magid *et al.* (2014) reported that the EC values of sewage effluent in Wadafea Treatment Plant at Khartoum North, Sudan, found to be ranged between 200 and 6200 µS/cm (mean TDS range of 1008-1621 mg/l), exceeding the allowable recommended standards for land disposal and irrigation reuse as set by the SSMO (2006). Abdel Magid *et al.* (2010) indicated a TDS range of 1008-1621 mg/l of sewage effluent at Soba Wastewater Treatment Plant, and attributed the increase of TDS level to the effect of evaporation from the surface of stabilization ponds, especially under the prevailing environmental conditions of high temperature and low relative humidity that leading to the accumulation of soluble salts. The high mean level of TDS indicates that the effluent water quality is unsuitable for sustainable irrigation or random disposal on land in order to avoid secondary salinization. Boyd (1990) stated that specific conductance for fresh water often range from 25 to 500µmhos/cm, hence values obtained in this study fall within the acceptable limits. In comparison as well, the observed values of the parameters obtained by this study fall within the WHO (1986) limits for good water for pond fish culture.

TSS mean levels of L_1 (386.4mg/l), L_2 (480.3mg/l), L_3 (401.5mg/l) and L_5 (226.4mg/l) samples were significantly higher than that of control sample (110.8mg/l), whereas it was slightly increased in the sample taken before discharge point (L_4, SOM=179.6mg/l) comparing to the control. Similarly TSS mean values for effluents (386.4 mg/l) were found to be higher than that recommended by SSMO (2006), which adopted the maximum allowable limit for TSS disposal into rivers and beach is to be 40 mg/l. In a previous studies (Akif *et al*., (2002) and Ali, (2004) were reported the TSS drain effluent of Suba Treatment Plant was found to be 422 mg/l. Means of TSS concentrations of raw influent of the Tertiary Wastewater Treatment Plant at Buraidah City, Saudi Arabia were ranged between 163.40 and 225.61 mg/l, whereas means of TSS for tertiary treated effluent were found sharply decline to range between 4.66 and 5.96 mg/l, indicating the high removal efficiency of the treatment plant (Al-Turki, 2010). The water of reservoir of Jabel Awleia Dam (the control sample L_0) is considered safe and quiet fit for inhabitant aquatic live. No other sort of any organic or inorganic pollutant was seen there. The TSS value is the only chemical parameter that found to be exceeded the recommended limits set by SSMO (2008) with regard to TSS; the potential source of TSS in the control sample can be associated to the excessive corrosion of earth and decomposition of plants caused by the high flooding rate during rainy season.

SOM mean levels of L_1 (7.58), L_2 (7.55), L_3 (3.67) and L_5 (8.99) samples were significantly higher than that of control sample (1.97), whereas it was slightly decreased in the sample taken before discharge point (L_4, SOM=1.68) comparing to the control (1.97). The high level of SOM may attribute to the high temperature. The higher level of both SOM and TSS imparts the effluent a dark brown color as previously reported by Ali (1993 and 2004). **DO** mean levels of L_1 (0.46 mg O_2/l), L_2 (0.39 mg O_2/l), L_3 (3.18 mg O_2/l), L_4 (5.82 mg O_2/l) and L_5 (5.86 mg O_2/l), whereas DO level in control sample was found to be 6.23 mg O_2/l. The level of DO in control sample was found to be significantly different comparing to level of site L_1, L_2 and L_3. DO is considered as a prerequisite for fish growth and survival, it is clear that the level of DO (6.23 mg O_2/l) in control water is a good quality for the sustenance of fish population. This result agrees with the result obtained by Ali (1993). The DO concentration of water is strongly affected by the presence of ox-disable matter and as such, is affected by the

dissolved organic carbon(DOC), the biochemical oxygen demand (BOD) and organic and in organic nitrogen concentration. Other factors that also affect the DO concentration are the temperature and the pressure (South African Water Quality Guideline, 1996). Less them 3 mg/l of dissolved oxygen is considered lethal for most of the organisms including fish (Ali, 1993)

Chemical analysis of water samples

Table 2 summarizes the chemical characteristics of water samples, the mean values of **TA** were: L_1 (580.0), L_2 (354.3) and L_3 (274.0) were found significantly higher than that of control L_o (117.9), whereas L_4 (103.2) and L_5 (102.3) were found less than the control. The SSMO (2002) did not set any guideline value for TA. With regard to **TH**, the mean levels of L_1 (102.9), L_2 (174.1) and L_3 (148.9) were found significantly higher than that of control L_o (62.4), whereas L_4 (60.5) and L_5 (63.3) were found to be almost equal to the control. The SSMO (2002) did not set any guideline value for TH. However, according to Viessman and Hammer (1985) water hardness of more than 300-500 mg/l is considered excessive for public water supply. Abdellah *et al*. (2012a) reported that the USGS (2009) classified water TH below 60 mg/l as soft water, and the range between 61 and 120 mg/l as moderately hard, while hard water is classified to be ranged between 121 and 180 mg/l.

In the present study, the mean levels of **Ca^{++}** in water samples were: L_1 (20.2 mg/l), L_2 (32.1mg/l), L_3 (37.1 mg/l) and L_5 (17.3 mg/l), these values were significantly higher than that of control L_o (10.6 mg/l), whereas L_4 (10.8 mg/l) were found to be almost equal to the control, indicating that the upstream discharge sample (L_4) was not affected with the effluent regarding Ca^{++} level. No standard and guideline value was set for Ca^{++} level in drinking water by SSMO (2002) and WHO (1993). Comparatively, these mean values of Ca^{++} in the investigated samples are considered low. Abdellah *et al*. (2012a) reported that Ca^{++} concentration of groundwater east of the Blue Nile River wells is ranged between 6 and 88 mg/l, and Abdel-Salam (1966) attributed the high concentration of Ca^{++} in groundwater east of the Blue Nile River to the weathering of basaltic rocks in the Ethiopian highlands. Abdel-Magid *et al.* (2014) reported that the sewage effluent at Wadefea Treatment Plant has greatly affected the soil Ca^{++} concentration level, and attributed that to the industrial wastewater disposed on land in the vicinity of the treatment station.

According to the data embodied in table 1, the mean levels of **Mg^{++}** in water samples were: L_1 (12.6 mg/l), L_2 (22.2 mg/l) and L_3 (13.7 mg/l), these values were significantly higher than that of control L_o (10.6 mg/l), whereas L_4 (8.1 mg/l) and L_5 (4.8 mg/l) were found to be below that of the control. The higher level of Mg^{++} in the sample taken from the canal (L_2), comparing to the rest, may be attributed to the soil erosion during effluent journey to the river. Abdellah *et al*. (2012a) reported that the mean level of Mg^{++} concentration of groundwater east of the Blue Nile River was 20 mg/l. No standard and guideline value was set by SSMO (2002) and WHO (1993) with respect to Mg^{++} level.

According to the data presented in table 1, the **Na^+** mean value of water samples: L_1 (249.4 mg/l) and L_2 (205.3 mg/l) found to be significantly higher than that of the control (L_o= 22.0 mg/l), whereas L_3 (36.0 mg/l), L_4 (31.1 mg/l) and L_5 (52.7 mg/l) were found to be slightly above that of the control, the drastic decline of Na^+ level in samples L_3, L_4 and L_5 indicates the dilution of the effluent by the river water. Abdel-Magid *et al.* (2014) reported that wastewater discharge of industrial origin increases significantly soil Na^+ concentration. Abdellah *et al*. (2012a) reported that the mean level of Na^+ concentration of groundwater east of the Blue Nile River was 52 mg/l. Standard and guideline value that set by SSMO (2002) and WHO (1993) with respect to Na^+ level in drinking water is 200 mg/l.

According to the data presented in table 1, the **K^+** mean value of water samples: L_o (10.6 mg/l), L_1 (29.9 mg/l), L_2 (12.1 mg/l), L_3 (16.2 mg/l), L_4 (11.0 mg/l) and L_5 (17.8 mg/l). Concentration of K^+ in sample taken from the treatment pond (L_1) found to be significantly higher than that of the control and the other samples, the relatively lower concentration level of K^+ in the other samples comparing to L_1 indicates the precipitation of K^+ in the treatment bond. Abdellah *et al*. (2012a) reported that, in general, K^+ concentration in the groundwater of east of the Blue Nile River is very low, where the mean level of K^+ concentration was found to be 5.6 mg/l. Potassium ion tends to be fixed again through sorption on clay minerals. The relative immobility of K^+ as related to Na^+ is due to the fact that K^+ enters into the structure of certain clay minerals and also due to the lesser rate of weathering of K^+ minerals compared to Na^+ minerals (El-Nazeer, 1987 and Rajkumar *et al.*, 2010). The SSMO (2002) did not set any guideline value for potassium.

The analytical data summarized in table 1showed that the highest level of **NO_3^-** in the samples under the study is 48.5 mg/l that found in the sample that taken from the treatment pond (L_1), seconded by the magnitude of 31.3 mg NO_3^-/l found in the water sample taken from the river discharge point (L_3). L_5 recorded 28.9 mg/l, L_2 was 16.4, and L4 amounted to 6.3 mg/l while the control found to be 6.4 mg/l. The guideline limit of 50 mg/l for NO_3^- set by the SSMO and WHO. Abdellah *et al*. (2012a) reported that when the NO_3^- contamination source is eliminated the NO_3^- level in the contaminated water will be diminishing as well. Accordingly, the highest NO_3^- level in sample L_1 found to be diminishing continuously by time while running

inside the canal (L_2). As previously stated by Abdellah (2014) that septic tanks, beside the industrial waste and sewage fluent, are another sources of nitrate contamination, and to avoid that he recommended legislators to enforce statutory laws (legislations) to organize the digging of sewage effluent disposal wells and to ensuring the proper disposal of organic and industrial wastes. Nitrate in excessive amounts affects water by expediting eutrophication that impedes growth of submerged aquatic vegetation necessary for nursery, spawning, and feeding for many species and by decreasing water's dissolved oxygen level, which is required by fish and other water organisms (Gardner and Vogel, 2005; Abdellah *et al*. (2012b).

The data presented in table 1 showed that $\mathbf{NO_2^-}$ mean values in water samples found to be almost like that of NO_3^-. The highest level of NO_2^- in the samples under the study is 13.800 mg/l that found in the sample that taken from the treatment pond (L_1), seconded by the magnitude of 11.500 mg/l found in the water sample taken from the river discharge point (L_3). L_5 recorded 10.03 mg/l, L_2 was 6.226 mg/l, and L_4 amounted to 0.026 mg/l while the control found to be 0.025 mg/l.

In this study the levels of $\mathbf{NH^-_3}$ in L_1 (24.83 mg/l), L_2(5.55 mg/l), L_3(20.27 mg/l) and L_5(16.30 mg/l), as shown in table 1, were significantly higher than the control (L_o=0.19 mg/l), no remarkable differences can be observed in sample L_4(0.23 mg/l) comparing to the control. Ammonia becomes more toxic as pH increases. Higher concentrations of the toxic form of ammonia (NH_3) are formed in basic waters; while the less toxic form, ammonium $(NH_4)^+$, is more prevalent in acidic waters. Since alkalinity increases pH, ammonia will be more toxic in waters with high total alkalinity. Hardness is not typically associated with ammonia toxicity (William *et al*., 1992) .The value observed in this study were higher than desired range and limits that recommended by SSMO (2006), and this may affect the growth of fish.

$\mathbf{Cl^-}$ levels in L_1 was 353.57 mg/l, L_2 was 233.03 mg/l, and L_3 was 18.03 mg/l were found to be significantly higher than that of the control (11.46 mg/l). No remarkable variation between L_4 (10.8 mg/l) and (L_5 was 11.57 mg/l) comparing to the control. A guideline level of 250 mg/l has been recommended by SSMO (2002) and WHO (1993) standards to be the maximum level for this element. Similarly, the decrease of the concentration level of Cl^- in samples of L_3, L_4 and L_5 comparing to L_1 and L_2 may be attributed to the dilution by the river water. The high concentration of Cl^- is considered to be an indication of pollution by sewage waste of animal origin. Industries are also important sources of chloride in water.

As shown in table 2, the levels of $\mathbf{SO_4^{-2}}$ were also significantly increased in L_1 (16.23 mg/l), L_2 (16.6 mg/l), L_3 (7.43 mg/l), L_4 (3.4 mg/l) and L_5 (5.53 mg/l) as compared to the control L_0 (1.64 mg/l), with higher mean 16.6 reported by L_2 (drain). The decrease of the concentration level of SO_4^{-2} in samples of L_3, L_4 and L_5 comparing to L_1 and L_2may be attributed to the dilution by the river water as well.

The $\mathbf{PO_4^{3-}}$ level was significantly higher in each of L_1 (10.15 mg/l), L_2 (4.75 mg/l) and L_3 (6.39 mg/l) were significantly higher than in control sample (L_0 = 0.22 mg/l). No remarkable variation observed between PO_4^{3-} level in sample L_4 (0.29 mg/l) and sample L_5 (0.46 mg/l) comparing to the control. The high decrease of the concentration level of PO_4^{3-} in samples of L_4, and L_5 can be affected by the river water. Phosphorus enters streams from wastewater treatment plant effluent. The surface water quality criterion for phosphorus is 0.1 mg/l, and this criterion shall not be exceeded in any stream unless it can be demonstrated that total phosphorus is not a limiting nutrient and will not render the waters unsuitable for the designated uses. The presence of phosphorus at levels higher than (WHO, 2008) guidelines is an indication of pollution of water in the areas by Sewage effluent discharge.

The levels of $\mathbf{S^{2-}}$ in water samples of L_1 (26.53 mg/l), L_2 (15.03 mg/l), L_3 (37.73 mg/l), and L_5 (3.40 mg/l) were also significantly increased as compared to the control L_0 (0.0 mg/l), whereas no difference was observed between L_4 (0.0 mg/l) and the control. The decrease of S^{2-} level in L_2 comparing to L_1 and L_3 may be attributed to the precipitation of S^{2-} in the clay soil while effluent running through the carrying canal. The concentration of sulfide at level 0.0 mg/l that found in both control and L_4 locations (before discharge) does not pose any threat to aquatic live. It has been stated by Khan *et al*. (1999) that the sulfide concentration higher than 1mg/l could be damaging to the fish, as it adversely affects the fish gills. Therefore, the high levels of $\mathbf{S^{2-}}$ that detected in samples L_1, L_2, L_3 and L_5 can pose a potential hazard to aquatic life. However, it was reported by Anon (1976) that sulfide values greater than 0.05 mg/l have caused complete mortality of fish. According to Chapman (1992) sulfide concentrations may not be of great importance if the pH is less than 10. Therefore, since the pH of White Nile River falls below 10, sulfide ions (S^{2-}) has negligible concentrations at this level of pH, because at low pH, sulfide exists as non- ionized molecules of hydrogen sulfide (H_2S) and hydro-sulfide $(HS)^-$.

The levels of **BOD** in L_1 (320.70), L_2 (277.60), L_3 (70.37), L_4 (2.57) and L_5 (27.0) were significantly higher than that of the control (0.57). The lower magnitudes of BOD levels in samples of L_3, L_4 and L_5 comparing the samples of L_1 and L_2 may be caused by dilution of the river water. Previous study conducted by Abdel-Magid *et al.* (2014) reported that in Wadafea Treatment Plant at Khartoum North, Sudan, the mean value for BOD for the year 2009 was found to be 1375.5 mg/l, while that for the year 2010 was 1212.6 mg/l. During

the year 2008, Al-Turki (2010) stated that the mean value of BOD concentrations of raw influent of the Tertiary Wastewater Treatment Plant at Buraidah City, Saudi Arabia, was found to be 208.51 mg/l, whereas means of BOD for tertiary treated effluent were found sharply declined to 4.32 mg/l, indicating the high removal efficiency of the treatment plant. The SSMO (2006) standard recommends a maximum allowable BOD level of 35 mg/l for discharge into rivers and beach after final treatment. It has been suggested by Khan *et al*. (1999) that a water containing BOD in the range of 1-3 mg O_2/l is almost pure and with a level of 5.0 mg O_2/l BOD it becomes doubtful. The BOD indicates a potential for reducing the DO content in water and this could result in organisms being stressed, suffocated and eventual death (APHA, 1995).

Whereas the levels of **COD** in L_1 (569.0), L_2 (442.23), L_3 (200.60), L_4 (30.53) and L_5 (69.83) were significantly higher than that of the control (15.56). The decrease of COD levels in samples of L_3, L_4 and L_5 comparing the samples of L_1 and L_2 may be caused by dilution of the river water as well. The previous study conducted by Abdel-Magid *et al.* (2014) reported that in Wadafea Treatment Plant at Khartoum North, Sudan, the mean value for BOD for the year 2009 was found to be 1375.5 mg/l, while that for the year 2010 was 2113.85 mg/l. Whereas Al-Turki (2010) stated that the mean value of COD concentrations of raw influent of the Tertiary Wastewater Treatment Plant at Buraidah City, Saudi Arabia, during the year 2008, was found to be 420.87 mg/l, whereas means of COD for tertiary treated effluent were found sharply declined to 16.27 mg/l, indicating the high performance of the treatment plant. The SSMO (2008) adopted the level of 35mg/l to be the higher limit for COD in wastewater; generally, it seems that the efficiency of the treatment plant, with respect of removing COD from the effluent, is lower than that of the BOD removal as mentioned above by Abdel-Magid *et al.* (2014).

IV. Conclusions And Recommendations:

The effluent wastewater from Industrial Military Factory and Soba Wastewater Treatment Plant does not meet both the local (SSMO) and international (WHO) standards. The high level of some of the parameters investigated in the present study renders the effluent from Industrial Military Factory and Soba Wastewater Treatment Plant as an unacceptable resource for reuse and negatively impacts the water quality of the White Nile River and poses hazard to the aquatic life and the public health at the surrounding environment. To utilize the effluent from Industrial Military Factory and Soba Wastewater Treatment Plant in irrigation successfully it is imperative to maximize the efficiency of this treatment plant to avoid notable environmental consequences. Stop pouring of wastewater into the White Nile River is of paramount importance.

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