Evaluation of some chemical properties of wastewater in Chad

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ABSTRACT

The objectives of this study were to determine some Physical and chemical properties of wastewater in N'Djamena city in Chad and to evaluate their impact on the environment. The Chemical parameters including dissolved oxygen and turbidity, Pb, As, Cd, Ni, and Cr. This study also aims to identify the health risks resulting from increasing concentrations (of these minerals).

Samples were collected from four different sites and analyzed according to standard methods. The results showed that the values of most parameters are beyond the World Health Organization recommended for wastewater discharge. Intensive investigations were recommended to cover the analysis of some chemical properties such as: SO_4^{-2}, NO_2^-, Cl^- and microbiological parameters, for better assessment the degree of pollution.

Keywords: Wastewater, Physicochemical Characterization, Pollution, N'Djamena

INTRODUCTION

Wastewater generally comprises liquid wastes produced by households, hospitals, restaurants, industries, etc., as a result of daily activities. Municipal treatment facilities are designed to treat raw wastewater to produce a liquid effluent of suitable quality that can be disposed to the natural surface waters with minimum impact on environment and human health. In developed countries where environmental standards are applied, much of the wastewater is treated prior to use for irrigation of fodder, fiber, seed crops, and to a limited extent for the irrigation of orchards, vineyards, and other crops. Meanwhile, though standards are set in developing countries, they are not always respected .Ullah and Jimenez (2010).

Since different water quality parameters need to be considered when evaluating wastewater effluents as a potential irrigation water source than those considered for its direct discharge into a receiving stream, a specific set of wastewater quality reporting requirements must be outlined and defined. Therefore, before using wastewater for irrigation as a means of increasing water supply for agriculture, a thorough analysis must be undertaken for a sustainable development strategy.

Untreated municipal wastewater in many quarters in N'Djamena city is used for the production of daily consumed vegetables. How safe is this practice? Hence, the objective of this study is to provide a review of the characteristics of wastewater used for irrigation and to carry out some physical and chemical characterizations of wastewater used to irrigate legumes that consumed daily in N'Djamena and evaluate their environmental impact.

Oxygen sources include dissolution of air oxygen by contact with water surface. Air contains 21% oxygen. As a result of photosynthesis, oxygen is released to be dissolved in water, and concentration is considered 5 to 6 mg/ l. which is suitable rate for most of warm water fish.

Turbidity results from colloids which are suspended in water. They are considered primary indicators of insoluble solids. It is used as a scale of the extent of wastewater quality. Turbidity is measured by product of salinity value by coefficient 0.67. as reported by Mustapha, and Adeboye (2014) and Rodier and Cloud (1996).

This study aims to indentify the health risks resulting from increased concentration and change in properties of the studied minerals with reference to the permissible limits.

MATERIALS AND METHODS

Materials Used

- Chromo Reactive (chrome chrom)Ver3m
- Nickel Reactive (phthalate-phosphate ; and 0.5 ml from Reactive PAN) and Reactive of Ethylene Di amine tetra acetic acid (EDTA)-
- Cadmium Reactive (Di hydro antraquinone acid 1, 2 and 3- Sodium sulfonates).
- Arsenic reacts with potassium iodine to form red complex.

Study site

The site of study is N'Djamena, the capital of the Republic of Chad. N'Djamena locates at latitude 12.8° N and 15.2° E longitudinal at an elevation of 295 m above the mean sea level. The main discharge channel "*la Cevette de Saint Martin*" is located in the middle of the town, it is a wide but not deep, it runs from northeast to southwest and drains into Chari River. The population of N'Djamena is about 993.492 habitats, distributed in 10 municipals. The study site included 4 locations; Diguel Ryad (DR) quarter in the municipal number 8 (Site 1), Paris Congo (PC) quarter in the municipal number 7 (Site 2), General Hospital channel (HGRN) in the municipal number 3 (Site 3) and the Chadian Brewery Company (STB) channel, Farcha quarter, in the municipal number 1 (Site 4).

Water sampling and analysis

The wastewater samples were collected during the season of 2014 from the 4 locations. Three samples per month from each location were collected at the same time (8:00 to 10:00 am) in a clean sterile plastic container and stored at 4ºC in the Laboratory of Analysis of Water and Environment, Faculty of Pure and Applied Science, University of N'Djamena.

Methodology

Dissolved oxygen and turbidity were measured according to the standard method APHA, (1998). And Five heavy metal (Pb, As, Cd, Ni, Cr) were analyzed using a spectrophotometer (HACH DR/2400) at different wavelengths, with Standard Methods for the Examination of Water and Wastewater according (USEPA ,1979).

Dissolved Oxygen

In this analysis, the electrochemical method of Rodier and Cloud (1996) in which oxygen was reduced in the suitable negative pole level, and generates electric current to match the partial pressure of oxygen inside the solution. dissolved oxygen was measured by field Oxy-Meter of HQ 30d type since it was directly submerged in the sampling site.

Turbidity:

Turbidity was measured using turbimeter ISO 2100P, SEPA, (2005) ; APHA, (1998) and EFSA, (2008) by shaking the samples well before measurement by the standard Néphélométrique method. Water turbidity results from existence of suspended particles, particularly mud, clay, silica particles and organic matters…etc. Concentration values of particles produce turbidity degree, according to Rodier and Cloud (1996).

Chromium (Cr)

Chromium was quantitatively and qualitatively detected according to (HACH-8023) 1,5-diphénylcarbohydrazide method since it allows measurements of concentration to extend from 0.01 to 0.07 mg/ liter of Cr^{+6} using pure chromium detector (chroma chrome) Ver3. This detector contains acidic medium related to 1,5-diphénylcarbohydrazide compound which reacts to create violet color in presence of chromium. Reading of the concentration of chromium is obtained at wavelength of 540 nm. Al Salman (1985) and Gamal , (2000).

Arsenic (As)

Arsenic in the sample was detected by diethyldithiocarbamate method. This method allows analysis of concentrations that range between 0 to 0.2 mg / liter of arsenic. Arsenic is reduced in the sample by mix of zinc and tin chloride. Arsenic reacts with potassium iodine to form red complex. The concentration of arsenic is colorimetrically estimated at wavelength of 520 nanometer using HACH- 8013. This method is approved by USEPA, (1979). for analysis of wastewater and drinking water.

Lead (Pb)

Fast method (Lead trak) was used to detect lead in the sample. This method allows analysis in concentrations that range between 5-150 µg / l. Soluble lead was first subjected to concentration in trak lead suppression column. Lead was extracted from the column and analyzed by lead detector using HACH – 8317 according to USEPA, (1979) and EFSA, (2008).

Cadmium (Cd)

In this part of the study, spectrum method was used to detect the toxic elements in water media according to the report of Ullah and Jimenez (2010) using light density meter (VIS/VIS SHIMADZU 1700 PC). In this method, red Alizarin detector (Di hydro antraquinone acid 1, 2 and 3-Sodium sulfonates) was used to react with sulfuric acid as it produces cadmium which is read at wavelength of 422 nm.

Nickel (Ni)

Nickel was detected using 1-(2 Pyridylazo) -2-Napthol (PAN); 8150 HACH. It allows measurement of concentrations in the range of 0.007-1,000 mg/ liter of nickel by adding phthalate phosphate powder detector and 0.5 ml of PAN as detecting solution by 0.3% in the sample. This detector reacts to create complex with various color between (yellow- orange- red). Ethylene Di amine tetra acetic acid (EDTA) dissolving powder detector is added in the sample, and reading for nickel concentration is obtained at wavelength of 560 nanometer or 620 nmas reported by Godin 2012 and Ullah and Jimenez (2010).

Table 1: Dissolved Oxygen (mg/l) and Turbidity (FTU) in wastewater of Diguel Ryad (DR)

Month	D0 (mg/l)	Turb. FTU
July	00.00	140 ± 1
August	4.28 ± 0.34	111.70 ± 2.36
September	4.27 ± 0.15	85.33 ± 1.15
November	1.62 ± 0.02	130.33 ± 0.58

Table 2: Dissolved Oxygen (mg/l) and Turbidity (FTU) in wastewater of Paris Congo (PC)

Month	D0 (mg/l)	Turb. FTU
July	00.00	328 ± 2
August	6.46 ± 0.52	98 ± 2
September	1.79 ± 0.75	36.67 ± 0.94
November	5.37 ± 0.02	98.33 ± 1.25

Table 3: Dissolved Oxygen(mg/l) and Turbidity(FTU) in wastewater of Reference General Hospital (HGRN) channel

Month	D0 (mg/l)	Turb. FTU
July	-00.00	104.33 ± 1.15
August	3.65 ± 0.21	32.33 ± 0.58
September	2.33 ± 0.08	225.67 ± 0.94
November	5.89 ± 0.01	48.00 ± 0.82

Table 4: Dissolved Oxygen (mg/l) and Turbidity (FTU) in wastewater of Chadian Brewery Company (STB) channel

Month	D0 (mg/l)	Turb. FTU
July	00.00	140.00 ± 1.00
August	4.00 ± 0.07	226.67± 2.89
September	0.33 ± 0.02	245.33 ± 1.53
November	1.24 ± 0.02	395.00 ± 1.00

RESULTS AND DISCUSSION

Dissolved Oxygen :

Level of dissolved oxygen in natural water at 20-25ºC is within the allowed limit (8-10 mg/ l) according to $WHO_{(b)}$ (1993). However, this level is affected by many factors, including water temperature, organic pollution level, concentration of salts in water, oxidation and reduction reactions (Amer et al, 2000) and Godin (2012) As shown in Tables (1, 2, 3 and 4), there is a fluctuation in the value of dissolved oxygen among sites. It is recorded in site 1 that highest reading in August was 4.28 mg/ liter, and the minimum reading was in November which was 1.62 mg/ liter. In sites 2, the values were in the range of 1.79 in September and 6.46 mg/ l in August. In site 4, it recorded the highest concentration in August with 4.0 mg/ liter, and the lowest concentration in September with 0.33 mg/ liter. The concentration of DO increased in August. This may be caused by increase of the annual rainfall rate and consequential increase of sites water. This is consistent with the arguments of Al Salman (1985) and Mustapha, and Adeboye (2014). In view of these results, we find that the direct effect on dissolved oxygen values is attributed to existence of sludge and particles that oxidize and consume oxygen, which is consistent with the statements of (Rodier and Cloud, 1996).

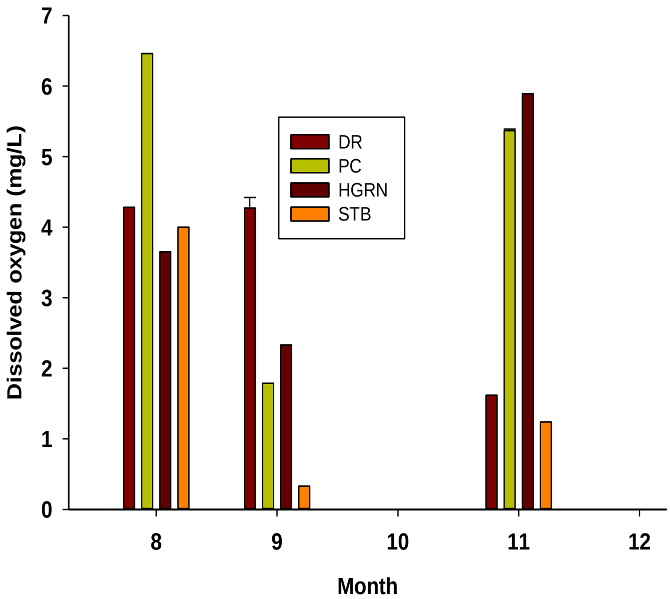

Figure (1): Dissolved oxygen of wastewater at four different sites in N'Djamena

Turbidity

The allowed limit of turbidity values according to the standards of the European community ranges between 1 to 10 FTU. Results showed that there is approximation in the turbidity values. In site 1, readings were in the range of 85 FTU in September and 140 FTU in July. Site 2 recorded the lowest readings in September 36.67 FTU and the highest reading 328 FTU in July . In site 3, readings were recorded in the range of 32.33 FTU in August and 226 FTU in September. In site 4, turbidity values were very high if compared to sites 1 and 2 which recorded the lowest reading in July 140 FTU and the highest 395 FTU in November. This confirms abundance of particles such as mud, clay, silica particles and organic matters in site 4. This is consistent with the statements of Amer et al, (2000) ; Mustapha, and Adeboye (2014).

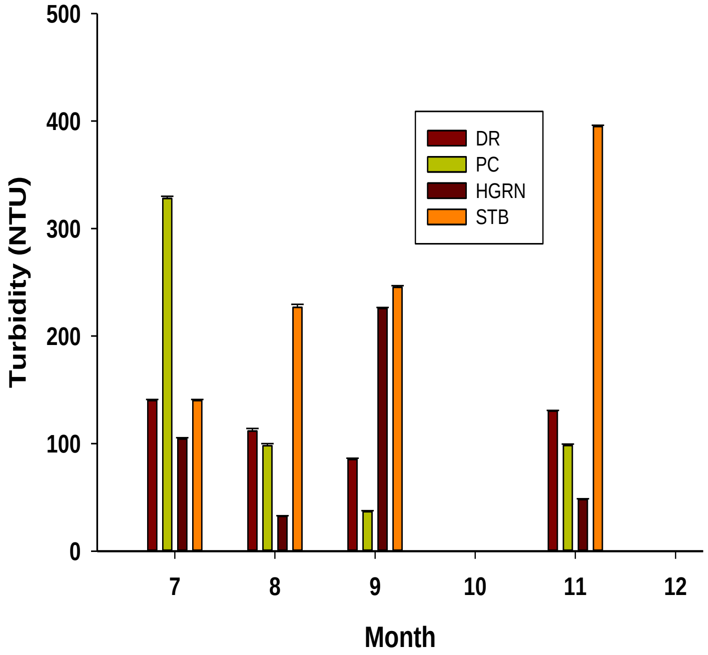

Figure (2): Turbidity of wastewater at four different sites in N'Djamena.

Table 5: Heavy metals concentration (mg/l) wastewater of Diguel Ryad (DR)

Month	Pb	As	Cd	Cr	Ni
July	138.00 ± 3.0	0.51 ± 0.04	0.54 ± 0.03	0.22 ± 0.01	1.80 ± 0.01
August	139.6 ± 1.63	0.52 ± 0.04	0.56 ± 0.01	0.18 ± 0.01	1.37 ± 0.06
September	159.33 ± 1.15	0.34 ± 0.01	1.83 ± 0.06	0.19 ± 0.03	0.98 ± 0.08
November	160.00 ± 1.00	0.34 ± 0.01	0.14 ± 0.01	0.23 ± 0.01	2.65 ± 0.18

Table 6: Heavy metals concentration (mg/l) in wastewater of Paris Congo (PC) channel

Month	Pb	As	Cd	Cr	Ni
July	140.00 ± 1.0	5.19 ± 0.04	0.34 ± 0.10	0.40 ± 0.01	3.76 ± 0.01
August	149.33 ± 1.15	5.20 ± 0.04	0.36 ± 0.04	0.12 ± 0.01	1.43 ± 0.03
September	10.00 ± 0.82	2.78 ± 0.02	n.d.	0.61 ± 0.02	2.35 ± 0.01
November	161.67 ± 0.47	1.78 ± 0.02	0.11 ± 0.01	0.10 ± 0.01	0.80 ± 0.04

Table 7: Heavy metals concentration (mg/l) in wastewater of Reference General Hospital (HGRN)

Month	Pb	As	Cd	Cr	Ni
July	92.00 ± 2.65	0.40 ± 0.02	0.10 ± 0.01	0.22 ± 0.01	1.66 ± 0.01
August	96.67 ± 0.58	0.40 ± 0.01	0.33 ± 0.03	0.12 ± 0.01	0.43 ± 0.01
September	95.00 ± 0.82	0.74 ± 0.01	n.d.	0.12 ± 0.01	0.57 ± 0.02
November	155.67 ± 0.47	0.72 ± 0.01	0.19 ± 0.01	0.03 ± 0.01	0.04 ± 0.01

Table 8: Heavy metals concentration (mg/l) in wastewater of Chadian Brewery Company (STB)

Month	Pb	As	Cd	Cr	Ni
July	105.00 ± 2.0	1.42 ± 0.09	0.63 ± 0.01	0.30 ± 0.01	2.06 ± 0.01
August	104.33 ± 0.58	1.43 ± 0.08	0.64 ± 0.02	0.59 ± 0.01	2.42 ± 0.06
September	4.33 ± 0.58	1.69 ± 0.05	0.013 ± 0.01	0.33 ± 0.01	2.17 ± 0.03
November	93.00 ± 1.00	0.66 ± 0.02	0.55 ± 0.01	0.23 ± 0.06	1.88 ± 0.03

n.d. not detected

Lead (Pb^{2+}).

Concentrations of Pb appeared to exceed the allowed limit of lead in wastewater 0.05 mg/ l according to $WHO_{(b)}$ (1993) or 0.01/mg/L in drinking water ; SEPA, (2005) ; Amer et al, (2000). and EFSA, (2008). Lead values varied to large extent among the four sites. In site 1 (Table5) values were in the range of 138±3.0 mg/ l in July to 160±1.0 mg/ l in November, and site 2 (Table 6) 10 mg/ l in September to 161 mg/ l in November. In site 3 (Table7), The lowest reading was recorded in July 92 mg/ l and the highest in November 156 mg/ l. In site 4 (Table 8), values were in the range of (4.33 mg/ l) in September and values were 105 mg/ l in July. The highest reading of lead was recorded in site 2 162 mg/ l. What interprets this high Concentration of lead is flow of polluted water in the place of maintenance of batteries and lead-containing products, in addition to the lead oxide vapors. This is consistent with the arguments of Ullah and Jimenez (2010).

Arsenic (As^{5+})

In 2001, Environmental Protection Agency (EPA) reviewed the rate which is allowed for arsenic in drinking water and reduced it from 50 ppb to become 10 ppb (Gamal 2000). In sites 1 and 4 (Tables 5 and 8), the highest concentration were recorded in September 1.34 and 1.69 mg/ l. In site 3 (Table 7), Concentrations were in the range of 0.40 mg/ l in July and August, and 0.74 mg/ l in September, and the highest Concentrations of arsenic was recorded during the period of the study in site 2 (Table 6) in August 5.20 mg/l. What interprets this concentrations incineration of the waste wood near to this site. Smoke which is produced by incineration of wood has previously been treated by arsenic as source of it. This is in agreement with the statement of Gamal, (2000). Arsenic enters into the body by respiration. Exposure to arsenic for long periods is a reason for bladder, lung, skin and liver cancer and nose, liver and prostate ducts. Exposure to low level of it leads to nausea and vomiting with irregular heartbeats and destruction of blood vessels (Zaki, 1999)

Cadmium (Cd^{2+})

Maximum allowed limit of cadmium in drinking water is 50 µg/ l (Amer et al, 2000). In irrigation water, it is 0.1 mg/ l, FAO (2008). In site1 (Table 5), values were in the range of 0.14 mg/ l in November 1.83 mg/ l in September. In sites 2, 3 and 4 (Tables 6, 7 and 8), highest readings were recorded in August (0.36, 0.33, and 0.64 mg/ l, respectively) and the lowest readings were in September for sites 2 and 3 (Table 6 and 7) (not detected). In site 4 (Table 8). reading was 0.013 mg/ l. These results show that the highest concentration of cadmium in this study exceeded the limit which is allowed in drinking and irrigation water. The reason for this may be attributed to erosion of water distribution network pipes by use of copper taps and lead connections which contain zinc and cadmium. Exposure to high concentration of cadmium causes kidney and lung diseases, osteoporosis and hypertension, in addition to problems of kidney functions and destruction of brain cells and cancer. Cadmium accumulates in the body even in low concentration as mentioned by Godin (2012)

Chromium (Cr^{2+})

All concentration that were recorded for the concentrations of chromium in the samples exceeded the allowed limit in drinking water 0.05 mg/ l according to $WHO_{(a)}$ (1993). and 0.1 mg/ l for irrigation water according to FAO (2008) and Intizar et al, (2014). Concerning this study, the minimum concentration was in the range of 0.03±2 mg/ l in November for site 3, and the maximum concentration was 0.61±2 mg/ liter in September for site 2. The remaining concentration are between these two values. In site1 (Table 5), values ranged between 0.18 mg/ l in August and 0.23 mg/ l in November. In sites 2, 3 and 4 (Tables 6, 7 and 8), the lowest readings were recorded in November 0.10, 0.03, 023 mg/ l respectively. The highest readings varied from 0.61 mg/ l in September, to 0.22 mg/ l in July, and 0.59 mg/l in August respectively. Through the highest two readings 0.61 mg/ l in September, site 2 (Table 6) appears to have sources of chromium, and that increase of chromium contributes to increase of the concentration of blood cholesterol because of its role in production of insulin and control of sugar according to Intizar et al, (2002).

Nickel (Ni^{2+})

The maximum allowed limit of the percentage of nickel in drinking water is 0.1mg/ l according to EU, (2011) and $WHO_{(b)}$ (1993) The lowest readings of sites 2, 3 and 4 were in November 0.80, 0.04 and 1.88 mg/ l, respectively, in site 1 (Table 5), the lowest reading of 0.98 mg/ l was recorded in September. The highest readings of sites 1, 2, 3 and 4 (Tables 5, 6, 7 and 8) were : 2.65 mg/ l in November, 3.76 mg/ l in July, 1.66 mg/ l in July, and 2.42 mg/ l in August. All those readings except for the reading of site 3 (table 7) exceed the allowed limit. The highest reading of nickel connections 3.76 mg/ l was recorded in site 2 (Table 6). This may be attributed to large number of beauty salons which use bleaching methods and hair colors in site 2 duct without treatment. This is consistent with the study of Gamal, (2000). Concentrations of nickel appear to increase in the samples of wastewater that were analyzed. This predicts environmental disaster because of its harmful effects.

CONCLUSION

The concentration of heavy metals in some was water in chad (water soluble form) and some physical properties included in this study. Results showed that there are some properties (As, Pb, and Ni) exceeded the permissible limits according to some international scientific institutions (FAO. EU, EFSA, CSHPF. USEPA). This rise exposes the health of the citizens to serious health risks such as all kinds of cancer, internal infections, anemia, heart and liver and kidney diseases since these minerals have the property of bioaccumulation in the human body ; Gamal, (2000); Al Salman (1985).and Intizar et al, (2002).

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تقييم بعض الخصائص الكيميائيه لمياه الصرف فى تشاد

Gamar M.G., Mohagir A.M., and Izat M. Taha

تهدف هذه الدراسة لتحديد أو الكشف عن بعض الخواص الفيزيائية والكيميائية لمياه الصرف الصحي لمدينة أنجمينا في تشاد. وكذا تقييم تأثيرها على البيئة، تشمل الخواص الكيميائية ;الأوكسجين الذائب، العكارة، الرصاص، الزرنيخ، الكادميوم، النيكل، والكروم. كما تهدف هذه الدراسة أيضاً للتعرف عن التراكيز المرتفعة للخصائص والمعادن المدروسة.تم جمع عينات مياه الصرف الصحي من ٤ مواقع مختلفة، ثم تحليلها وفقاً للطرق القياسية. وأظهرت نتائج التحاليل أن قيم معظم العناصر المدروسة تتجاوز حدود منظمة الصحة العالمية لمياه الصرف الصحي المقذوفة. وتتطلب تكثيف التقصي لهذه المياه تحاليل شملت بعض العناصر الكيميائية مثل: الكبريتات، النتريت، الكفور والمعايير المايكرو بيولوجية. وذلك بهدف تقييم أفضل لدرجة التلوث .