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Physico-Chemical Evaluation of Wastewater from Abattoir, Brewery, Soap and Oil Factories, at Moundou City in Southern Chad

Ahmatal Tidjanihisseine, [1]Richard KAMGA, [2]TCHADANAYE New Mahamat[3]
[1.] Faculty of Pure and Applied Sciences, Department of Chemistry /University of N'Djamena Chad.
2. Professor**,** Department of Applied Chemistry *in ENSAI of University of Ngaoundéré Cameroon.*
3. Senior Lecturer, Department of Chemistry, Faculty of Pure and Applied Sciences /University of N'Djamena Chad.

Abstract
The discharge of industrial wastewater in the city of Moundou deteriorates the quality of surface and underground water and soils. In this study the physicochemical quality of industrial effluents was investigated in different seasons (summer, winter and rainy). Three sampling sites were used (Central Abattoir discharge, Cotontchad (soap and oil factory) discharge, and Brewery discharge), for sampling from July 2013 to December 2014. The following physico-chemical parameters were determined: pH, Temperature, EC, dissolved oxygen, COD, BOD_5, NO_3,PO_4,SO_4. Also, the heavy metals: Cu, Cd, Mn, Ni, Pb, As, Zn, Cr, Fe, Al, was analyzed on spectrophotometers and results were compared with World Health Organization (WHO) permissible limits.
This study revealed that most parameters were much higher than the permissible limit for wastewater discharges:some parameters were to higher: pH (12,6), Temperature (37,8 °C), C.E (4270 µS/cm), organic matters: COD (1200 mg/l), SO_4 (1280 mg/l), PO_4(4460 mg/l), NO_3 (63,6 mg/l), (Fe (63,34 mg/l), Zn (13,27 mg/l), Pb (4,0 mg/l), Cu (25,34 mg/l), Cd (31,78 mg/l), Cr (5,9 mg/l), Ni (39,5 mg/l. The study concludes that discharge of effluents by the companies; factory and materials from other anthropogenic sources severely pollute the Logone River with heavy metals and other pollutants. We recommended that each industry recycle its wastewater and put in place specific treatment plants, because pollutants to eliminate vary depending on the industry.

Keywords*: Pollution, Industrial Effluent, Heavy Metals, Physico-Chemical Parameters, Moundou, Chad.*

I. Introduction

Industries are major sources of pollution in all environments. Based on the type of industry, various kinds of pollutants can be discharged directly or indirectly into the environment (Tilt, 2013). Wastewater from industry may include sanitary waste of employees, processing waste from manufacturing plants, water emanating from washing the factory floor as well as those utilized in various cooling systems (Awaleh and Soubaneh, 2014). Sources may vary widely depending on the size of the industry and what is being produced. Present estimates indicate that consumable water constitutes 1% of the earth's total water resources, and ground water levels are increasingly being threatened by pollution directly and indirectly (Kumar and Suneetha, 2014).

Environmental pollution due to contamination of river water (thereby degrading also the groundwater) is a major problem in many developing countries, as the maintenance of water quality and sanitation infrastructure often does not increase commensurately with population and urbanization growth. Rapid urbanization and industrial development during the last decade have provoked some serious concerns for the environment. Heavy metals contamination in rivers is a major quality issue in many fast-growing cities (Sundaray*et al.*, 2006; Karbassi*et al.*, 2007; Akoto*et al.*, 2008; Ahmad *et al.*, 2010).

Heavy metals are classified as metallic elements that have relatively high atomic weight and are poisonous at low concentrations. They are natural components of the earth crust, and cannot be degraded or destroyed (Lentech, 2011). Specifically, heavy metals are those having density greater than 5 gcm^{-3}. Most often this term denotes metals that are toxic: these include Al, As, Cd, Cr, Co, Pb, Hg, Ni,Se, Cu, Mn and Zn (Rodier, 1975). Some heavy metals are naturally present in some natural water sources. Some are essential for health of living organisms (such as cobalt, copper, and manganese), but when their concentrations surpass tolerable limits, they become toxic.

These metals or their compounds may be discharged into surface water from industries, farmlands, municipal urban water runoffs, and agricultural activities. Sources include a large variety of raw materials, by-products, co-products, and final

products of human activities. Many of these wastes find their way into land water/sediments and air. Pollution of streams and rivers flowing through agricultural areas where pesticides, fungicides and herbicides have been applied, and industrial districts where organic and inorganic waste has been deposited, causes further problems due to drainage into different water bodies. Effluents discharged into a river, may affect aquatic life either directly orindirectly (Ademoroti, 1996).

In Chad most industries are situated along the riverbanks for easy availability of water as well as waste disposal. These wastes often contain a wide range of contaminants such as petroleum hydrocarbons, chlorinated hydrocarbons and heavy metals, various acids, alkalis, dyes and other chemicals which greatly change the pH of water. The waste also includes detergents that create masses of white foam in river waters. Wastewater from industries contains enormous quantities of pollutants such as nitrates, nitrites, cations, anions and toxic metals such as Fe (iron), Cr (chromium), Cd (cadmium), Cu (copper), Zn (zinc), etc., (Sial et al., 2006; Ullah et al., 2009). Biological Oxygen Demand (BOD) is a measure of the amount of oxygen that bactria will consume while decomposing organic matter under aerobic conditions, while Chemical Oxygen Demand (COD) does not differentiate between the biologically available and inert organic matter (Lenore *et al*, 2005; Malik *et al*, 2014). On the other hand, organic nitrogen contained in organic matter is converted into ammonia (NH_3) or ammonium salts (NH_4^+), according to a bacterial process called ammonification. Nitrification of ammonium is performed under aerobic conditions; the demand for oxygen it carries is added to the final BOD (Champoux and Toutant, 1988). The lack of oxygen causes the opposite phenomenon, called denitrification: NO_3^- is transformed into nitrite (NO_2^-) which is toxic, or to molecular nitrogen (N_2) (Gingras, 1997). This oxygen consumption leads first to a decrease in oxygen levels in the water. When the rate of oxygen saturation falls below 6 mg/L, fish life is threatened. Below 5 mg/L, most species die (Champoux and Toutant, 1988).

Tchoroun, 2012 studied the effluents of the Cotontchad factory and brewery of Moundou, and reported that certain parameters were higher than recommended value set by WHO.

The objective of this study is the evaluation of wastewater discharged into Logone River from the brewery of Chad (BDT), the soap and oil factory of Cotontchad, and the central abattoir of Moundou, and their ecotoxic effects through various physico-chemical parameters, in order to determine the degree of pollution from each industry and thus inform recommendations for specific strategies for each industry to fight against these sources of pollution.

II. Methodology

2.1. Area of Study

Moundou, the capital of Logone occidental region in south of Chad, is located at 400Km from N'Djamena the capital, at latitude 8.550°N and longitude 16.090°E. The town is located beside the Logone River. Industries based in Moundou, Chad's most important industrial company, Cotontchad, gins cotton and manufactures soap and oil from cottonseed. Cotontchad also has ginning operations in several large southern towns. In addition to Cotontchad, Moundou has a cigarette company and a firm that assembles agricultural equipment. The Logone River which is the study area of present investigation receives a heavy pollution load from nearby Moundou industrial area, which is one of the most rapidly developing and heavily polluted industrial belts of Chad. Liquid discharges form industrials sources are discharged directly into the river. Simultaneously, resident farmers use river water for drinking and irrigation of cereal and forage crops.

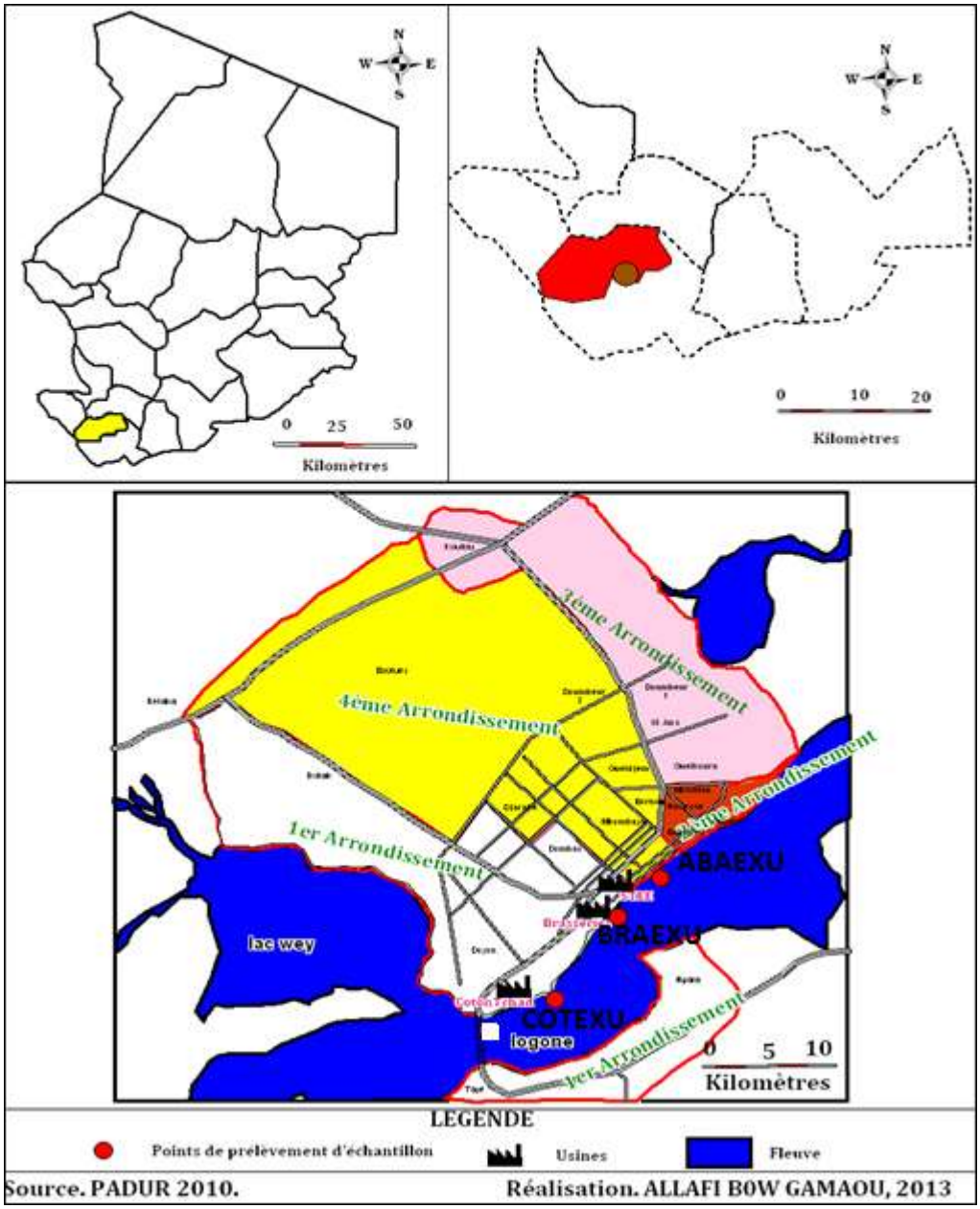

Figure 1. Sampling location map of study erea

The stations selected for the study are as follows;

- Point 1 (ABAEXU), is the wastewater of central Abattoir of Moundou, the main wastes originate from killing, hide removal or dehairing, paunch handing, trimming processing and cleanup operations. The wasted contain blood, grease, inorganic and organic solids, and salts and chemicals added during processing operations.
- Point 2 (COTEXU), shows the liquid discharged from COTONTCHAD factory that produces; laundry soap, cooking vegetable oil from cottonseed, and textile (waxing).
- Point 3 (BRAEXU), represents the liquid discharges from Brewery of Chad (BDT) that produces: mineral water, soft drinks (syrup manufacture), malt, and alcoholic beverages (beer).

2.2. Water Sampling and Preservation

2.2.1. Sampling methods and analysis

Wastewater samples were collected before mixing with Logone River water with 250 ml polyethylene bottles which were previously washed with detergent, rinsed with distilled water. During sampling, sample bottles were rinsed with sampled water three times and then filled to the brim from each of the designated sampling points. Temperature, pH, and dissolved oxygen were measured immediately after collection.

The determination of the following physicochemical parameters: pH, Temperature, EC, dissolved oxygen in situ, NO_3,PO_4, SO_4 and heavy metals, Cu, Cd, Mn, Ni, Pb, As, Zn, Cr, Fe, Al, and Mo. were done by spectrophotometer (HACH DR/2400) and leader of water analysis spectrophotometer 7100 UK, Cadmium was assayed by the method of molecular absorption spectrophotometer at 422 nm against reagent blank using a spectrophotometer (SHIMADZU UV-1700 PC).The determination of COD was made by digestion of potassium dichromate in a DR/2400 HACH digester at 150°C for 2 h and results were obtained on a DR2400 spectrophotometer at a wavelength of 620 nm (Hach, 1997). $BOD_5$was determined by the respirometric BOD Trak^{TM} 2000. A 160 mL, aliquot of each sample was introduced into a BOD bottle on the BOD Trak and incubated at 20°C for 5 days. Readings were made on the screen of the BOD TrakAQUALATIC (Hach, 1997).

The study of the pollution was based on the analysis of physicochemical parameters. These parameters were obtained from analysis in Laboratory of Water and Environmental Analysis (LABEEN) of faculty of Pure and Applied Science (FSEA) of the University of N'Djamena.

Statistical analysis of data: in our present study we determined the covariance and Pearson correlation coefficient R using Microsoft Office Excel (Microsoft 2010), and analysis of variance (ANOVA) was done using statgraphic 16.

III. Results and Discussion

The experimental data on heavy metal content and physico-chemical properties of water samples collected from three anthropogenic activities effluent flowing Moundou industrial zone is presented in Tables 1 and 2.The ratio of mean concentrations to background values for most of metals where larger than 1,0 mg/l and are ranked in the following order: Fe> Ni> Cu > Zn> Cr > Pb > Mn. This means that effluent discharge from the industries has significant effects on the concentrations of metals in Logone River water over the area. And the water is contaminated by these metals.

Table 1: physicochemical parameters of wastewater from industries in city of Moundou

Date of Sampling	Station effluents	pH	Tempra °C	C.E (µS/cm)	Sulfates (mg/l)	Phosphates (mg/l)	Nitrates (mg/l)	Nitrite mg/l	Fluore mg/l
12/07/2013	**M_1**	11,50	37,8	1552	55	1,78	7,2	Nd	0,01
	M_2	7,33	25,0	348	150	2,33	14	Nd	3,09
	M_3	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
30/05/2014	**M_1**	4,57	Nd	466	45	185	22,5	Nd	Nd
	M_2	12,60	Nd	4540	1280	548	63,6	Nd	Nd
	M_3	6,4	Nd	4270	490	904	17,4	Nd	Nd
8/12/2014	**M_1**	11,50	34,60	973	36,34	194,34	0,827	380	1,11
	M_2	6,94	31,1	145,2	1	13,067	0,000	0,000	0,29
	M_3	6,83	24,6	69,8	816,67	426,67	18,6	1050	1,8
11/12/2014	**M_1**	10,51	33,5	977	28	210,67	0,967	86,67	0,5
	M_2	9,36	30,9	537	633,34	796,34	21,34	766,67	0,00
	M_3	7,12	24,4	55,3	886,77	4460	33,67	3500	0,07
16/12/2014	**M_1**	9,87	36,7	237	486,67	622	10,74	2233,4	2,1
	M_2	9,36	30,9	537	138	350	4,534	216,67	0,2
	M_3	7,12	24,4	Nd	Nd	Nd	Nd	Nd	Nd
WHO permissible limit		6.5-8.5	30 °C	1000 µS/cm	250 mg/l	5 mg/l	50 mg/l		1.5 mg/l

M_1; Brewery effluents; **M_2**; Cotontchad effluents;**M_3**; Abattoir effluents.

pHis a measure of the acidity or alkalinity of water and is one of the stable measurements. pH is a simple parameter but is extremely important, since most of the chemical reactions in aquatic environment are controlled by any change in its value. Anything either highly acidic or alkaline would kill aquatic life. Aquatic organisms are sensitive to pH changes and biological treatment requires pH control or monitoring. The toxicity of heavy metals also gets enhanced at particular pH.Thus, pH is having primary importance in deciding the quality of waste water effluent. Waters with pH value of about 10 are exceptional and may reflect contamination by strong base such as NaOH and $Ca(OH)_2$(D. Langmuir, 1997).

The results revealed that in most of the sampling stations, wastewater was slightly alkaline except at very few stations like abattoir effluents where the water was found to be slightly neutral. The range of pH was 4, 57 for effluent of brewery inMay summer

(dry season) and 12,60 for Cotontchad factory discharge during the month of May. This high value could be from using of costing used in production of soap. In the table of ANOVA there are significant differences between the values of pH. The pH= 11,5 of brewery effluents could be as a result of somechemicalspreservativesusedinbrewerysuchasSulphurdioxide and carbon dioxide which in turn from Trioxosulphate (iv) and Carbonic acid, on reaction with waterrespectively.The above values usually indicate the presence of carbonates of calcium and magnesium in water (Begum *et al.*, 2009). Cotontchad and Brewery effluent were higher than WHO limit; thisis not surprising since the brewery process requiresbasic detergents for the cleaning stage.

The temperature of the discharged factory effluents ranged between 24,4°C for central abattoir of Moundou and 37,8 °C for discharged water of Brewery (BDT). There is any value of probability ender 0,05 , any factor not have statically significant in temperature in level of confidence of 95,0%. This is also within the Federal Environmental Protection Agency (FEPA) permissible limit of less than 40^{o}C.These hightemperature values were likely have been generatedby the brewery activities which included boiling of worth, pasteurization of water as well as the washingand rinsing of returned bottles in hot and warm waterrespectively.. WHO recommend a value of 30°C for wastewater.

Cotontchad effluent recorded very lowdissolved oxygen (DO) 3,88mg d'O_2/l, because it carried inorganic and organic matter and in decomposition of organic matter DO was consumed by microorganisms.

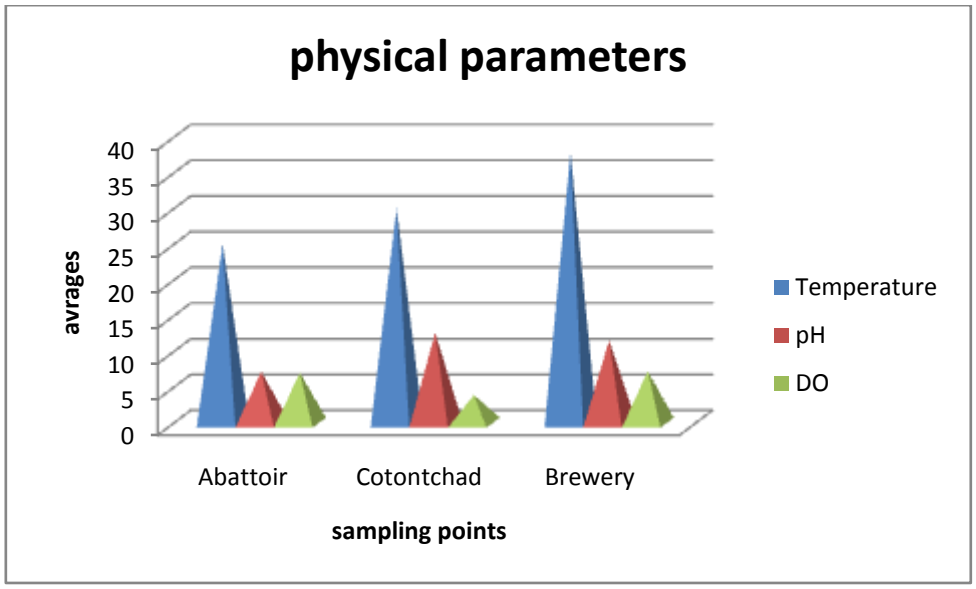

Figure1. Average values of physical parameters in industrial effluents in Moundou

2.5 Electrical conductance (EC)

EC is the measure of the ability of an aqueous solutionto convey an electric current. This ability depends uponthe presence of ions, their total concentration, mobility,valence and temperature.Electric conductivities are very important for the control of wastewater pollution level. The EC values in the present study were ranged on average between 1552 µS/cm for effluents discharges from Moundou Brewery in July 2013, and 4540 µS/cm for wastewater of Soap and oil factory of Cotontchad in Dry season in May 2014, and 4270 µS/cm for discharges of Central Abattoir. Highest EC was recorded in the effluent of Cotontchad and Abattoir and Brewery because it contained many chemicals, salts and dissolved solids (Mishra and Saksena, 1993).According to Nisbet(1970), these values showed a strong mineralization of discharges.

BOD_5,and COD: COD is Chemical Oxygen Demand, which gives an indication of oxidiable organic matter present in the sample. BOD and COD indicate the pollution of water by oxygen depletion (Sridhar and AdeOluwa, 2009; Awotoye*et al*., 2011; Okwute and Isu, 2007; Ahmad *et al*., 2003; Khalid and Wan Mustafa, 1992; Hartley, 1988). In our study the Central Abattoir has a BODranged between 548 mg/L in December and 614 mg/L in May; COD between 109 mg/L and 801mg/L (Fig. 2). High COD values could be due to highorganic load in the discharge of Central Abattoir (Table 2). The Brewery has a BODbetween 34 mg/L and 626 mg/L in December; COD value between 10,67 mg/L and 923mg/L (Fig. 2). These values are higher than those prescribed by the standard (Table 1). The Soap and oil factory of Cotontchad has DBO between 30mg/L

in December and 1070 mg/L in July. High BOD will lead to oxygen depletion, which can have severe consequences on fish life in the Logone River. (Osibanjo et al., 2011); COD value between 227,67 mg/L and 1200 mg/L. The high levels of COD in the effluents of Cotontchad indicate the release of material with high chemical oxygen demand and may impact the sustainability of the discharge sources negatively if they will be continuously discharged without proper treatment.These values indicated that the load of wastewater organic substances studied set well beyondof maximal concentrations permissible limits for pollutants (Table 1). So, the values of COD and BOD5 are beyond recommendations of WHO which set 90 mg/L for COD and 30 mg /L for BOD5, concerning wastewater discharge (Table 1).

These high COD and BOD concentrations observed in these wastewaters might be due to the use of chemicals by the industries. High BOD and COD are responsible for the odorous nature of industrial areas where effluent discharges are widespread. Consequently, the bad odor in the study area could be attributed to high COD.

Sulphate ions concentration (SO_4^{2-})

Sulphates cause water hardening and therefore high levels are not recommended. All industries should be encouraged to ensure that it is kept under control. All industries that omitted to report this parameter should be encouraged to analyses it their subsequent audits. Sulphate usually occurs in natural water. The presence of Na_2SO_4& $MgSO_4$ in drinking water beyond the prescribed limit may cause cathartic action. Sulphate may undergo transformations to hydrogen sulphide depending largely upon the redox potential of water. This is also an important anion imparting hardness to the water. In the present study the SO_4^- ion concentration in the studied wastewater samples was found to be 1280 mg/lit for discharges of Cotontchad factory in May; 486.67 mg/l for effluent of Brewery in December (winter); and 886.77 mg/l for discharges of Central Abattoir of Moundou. All values were exceeds the WHO permissible limit which is 250 mg/l.

Phosphatesions (PO_4^{2-})

Phosphate concentration was found to be high at the point of effluent discharge (4460 mg/l) for Central Abattoir;

Nitrate ion concentration (NO_3^-)

The resources of nitrate come from oxidation of other form of nitrogen like ammonic, nitrite, to nitrate. Agrawal (1999) reported that if the concentration of nitrate more than 0,5 mg/L it is an indication of pollution. In the present study the concentration of nitrate for Central Abattoir effluent ranged between 33,67 mg/l in December and 53,1 mg/l in May. For Brewery discharges ranged between 0,827 mg/L in December and 22.5 mg/L in May. For discharges of Cotontchad the concentration of nitrate ranged from 4,534 mg/l in December and 63.6 mg/L in May. From these results we conclude that Cotontchad, use a high quantity of organic matters to produce soap and vegetable oil and reject large quantity of Nitrate in Logone River.

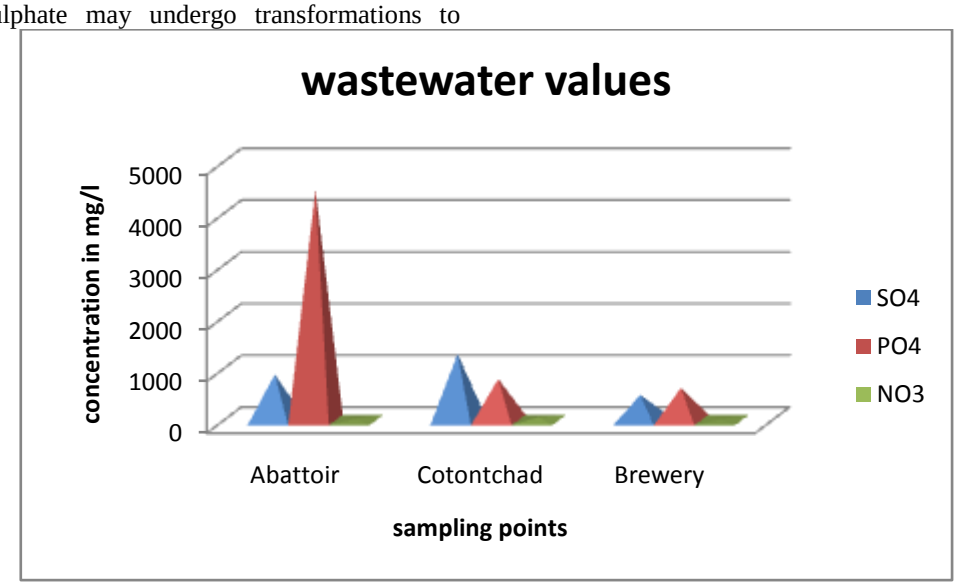

Figure 2. Variation in average physicochemical parameters in industrial wastewater inMoundou.

Table 2: Heavy metals of the wastewater of Brewery, Cotontchad and Abattoir industries in Moundou

Date of Sampling	Heavy metals	Brewery	Cotontchad	Central Abattoir	Permissible limits (WHO)
12/07/2013	Fe	4,36	7,74	Nd	0,30 mg/l
	Zn	1,05	2,87	Nd	5 mg/l
	Pb	0,002	0,102	Nd	0,01 mg/l
	Cu	Nd	Nd	Nd	0,05 mg/l
	Cd	0,0138	0,0660	Nd	0,01 mg/l
	Cr	0,39	0,71	Nd	0,05 mg/l
	As	0,14	0,08	Nd	0,01 mg/l
01/06/2014	Fe	8,40	62,00	50	0,03 mg/l
	Zn	0,98	3,00	9,30	5 mg/l
	Pb	4,00	1,900	0,018	0,05 mg/l
	Cu	1,20	18,50	18,0	0,05 mg/l
	Cd	0,330	7,667	Nd	0,01 mg/l
	Cr	0,32	0,55	4,2	0,05 mg/l
	Mn	0,004	0,10	0,06	0,5 mg/l
08/12/2014	Fe	0,216	0,150	51	0,30 mg/l
	Zn	0,556	0,00	11,24	5 mg/l
	Pb	4,00	1,900	0,00	0,05 mg/l
	Cu	0,814	0,080	22,67	0,05 mg/l
	Cd	0,330	0,684	31,78	0,01 mg/l
	Cr	0,197	0,05	5,967	0,05 mg/l
	Ni	2,20	0,00	32,5	0,1 mg/l
	Mn	0,0034	0,00	0,060	0,5 mg/l
11/12/2014	Fe	3,267	29,6	63,34	0,30 mg/l
	Zn	1,004	4,00	13,27	5 mg/l
	Pb	4,00	1,190	0,00	0,05 mg/l
	Cu	1,584	7,78	25,34	0,05 mg/l
	Cd	0,330	0,684	31,78	0,01 mg/l
	Cr	0,43	1,234	8,667	0,05 mg/l
	Ni	3,117	10,67	1,5	0,1 mg/l
	Mn	0,272	0,034	0,004	0,5 mg/l
16/12/2014	Fe	7,87	7,667	63,34	0,30 mg/l
	Zn	3,2	1,567	13,27	5 mg/l
	Pb	4,00	1,90	0,00	0,05 mg/l
	Cu	10,03	4,934	25,34	0,05 mg/l
	Cd	0,330	0,684	31,78	0,01 mg/l
	Cr	1,8	0,927	8,667	0,05 mg/l
	Ni	14,5	1,5	1,5	0,1 mg/l
	Mn	0,064	0,272	0,004	0,5 mg/l
	As	0,78	0,94	0,517	0,01mg/l

Cr: Chromium causes cancer, dermatological disorders and anemia. We obtained the following concentrations: 8.667 mg/L for discharges of the Abattoir; 1.8 mg/L for discharges of the Brewery and 1.234 mg/l for discharges of Cotontchad. All discharges of anthropogenic activities have high concentration than the permissible limit recommended by HWO which is 0, 01 mg/L (Benedetto, 1999, and Rodier*and al.*, 2009).

Cd: Cadmium causes respiratory and kidney problems. During the present study, maximum concentration, our results are 3,30mg/L in the effluents released from the Brewery (BDT), 0,684 mg/L for the Cotontchad discharges and 3,178 mg/L for Abattoir effluents (Fig. 3). All have values above WHO permissible limit for cadmium which is 0,01 mg/l Benedetto (1999) et Rodier and al., 2009.

Pb: Exposure to lead causes a variety of health effects, and affects children in particular. Water is rarely an important source of lead exposure except where lead pipes, for instance in old buildings, are common. Removal of old pipes is costly but the most effective measure to reduce lead exposure from water. Plumbin water could be conceived to mainly originate from industrial and domestic discharge of wastes in the river and is non-essential for plants and

animals and is toxic by ingestion-being a cumulative poison, producing damaging effects on the kidney, liver, tissues, blood vessels, nervous system and depresses sperm count (Anglin-Brown et al., 1995; Tijani et al., 2004). The concentration of Pb in discharges of Brewery of Moundou ranged from 0,002 mg/L in July and 4,00 mg/L in December; For the discharges of Cotontchad the concentration of plumb varied from 0,102 mg/L in July to 1.9 mg/L in December. For discharges of the central Abattoir the values obtained in this study ranged between 0,000 mg/L to 0.018 mg/L. Pb poisoning also causes neuromuscular and central nervous system disorders (Kaur, 2012).

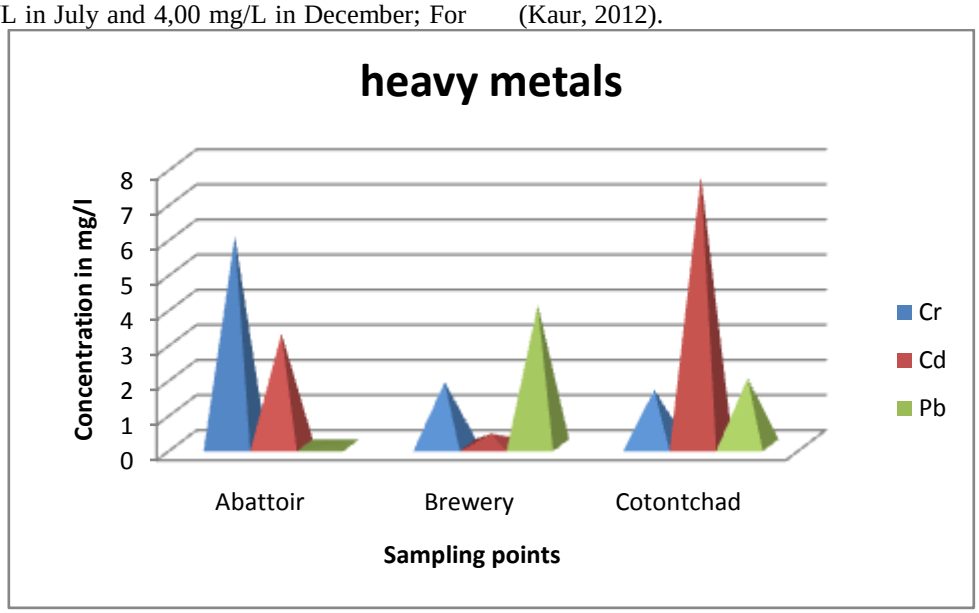

Figure 3. Variation in average of Cr, Cd, and Pbin industrial wastewater inMoundou.

Fe: In fact, if one wants to avoid all the disadvantages (taste, color, precipitate and tasks on the machine), the water supply should not have iron. For our analysis this concentration is 63,34 mg/L for discharges of the Central Abattoir of Moundou, 8,40 mg/L for those of Brewery and 62, 00 mg/L for Cotontchad (Fig. 4).The observed levels of Fe in the industrial effluents discharged from different industries were above the permissible limit of 3.00 mg /l recommended by HWO (Table 2). The highest concentration of Iron in Abattoir discharges could be explained for high volume of blood which contain iron ion in discharges. Followed by Cotontchad factorydischarge, and finally discharges of Brewery. These concentrations are harmful to storage tanks. The analysis of Variance (ANOVA) indicate that F test was superior or equal 0,05 there are not statically significant difference between median of the three points of sampling at confidence level of 95,0%.

Zn: Zinc is used in a number of alloys including brass and bronze, batteries, fungicides and pigments as well as in galvanizing steel and iron products (Jose *et al.,* 2005).Toxicity to fish occurs from a few milligrams per liter. For agricultural use, the deterioration of the plants can occur from 5 mg/L. For the wastewater studied the zinc content is 3,20 mg/l as maximal concentration for the Brewery discharges, 4,00 mg/L for the effluents of CotontchadCOT and 13,27 mg/L for the Abattoir discharges. Release of Abattoir, Cotontchad and Brewery were high than 3 mg/l the permissible limit of HWO for zinc (Gaouti*and al.,* 2005), these wastewater discharge flow into the Logone River, where fish killed had been remarked by the population of the city of Moundou. Based on our results releases of the Abattoir, could be at the origin of the death of the fish reported above.The analysis of Variance (ANOVA) indicate that F test was inferior of 0,05 there are statically significant difference between median of Zn in the three points of sampling at confidence level of 95,0%.

Cu: The maximal values found in this study are: 10,03 mg/L for discharges of the Brewery, 18,5 mg/L for discharges of the Cotontchad and 25,34mg/L for discharges of Abattoir (Fig. 3). The values are higher than those prescribed by WHO (Table 2). Abattoir has the highest value (Fig. 3). Copper in the dissolved form is potentially very toxic to aquatic animals and plants, especially to young life-stages such as fish larvae. The toxicity of copper is however greatly reduced when it is bound to particulate matter in the river water and when the water is hard. The industries and public should recognize the need to monitor the concentrations in discharges and in rivers closely, to ensure that Water Quality Objectives are not exceeded.The analysis of Variance (ANOVA)

indicate that F test was inferior of 0,05 there are statically significant difference between median of Cu in the three points of sampling at confidence level of 95,0%.

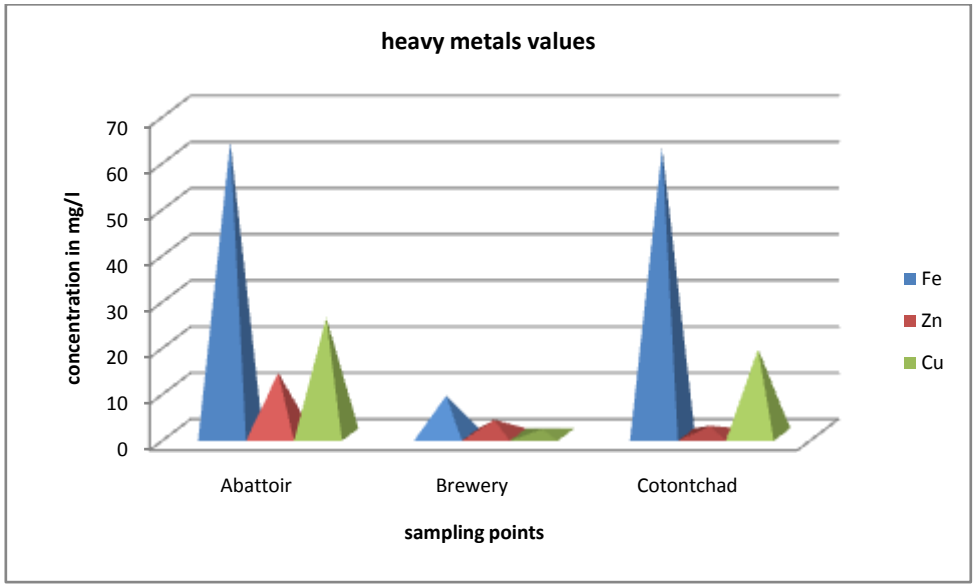

Figure 4. Variation in average of Fe, Zn, and Cu in the industrial wastewater in Moundou

Ni: Nickel is a well-known neurotoxic, genotoxic and carcinogenic agent which may cause health problems like nickel dermatitis, giddiness, diarrhea, degeneration of the liver and various types of cancer (Das *et al*, 2008).Our analysis gives us the following concentrations: 14.5 mg/L for discharges of the Brewery, 24.0 mg/L for discharges of the Cotontchad and 39,5 mg/L for discharges of the Abattoir (Fig. 5). All its levels are above the norm of 0,01mg/L recommended by WHO(Table 1), they are harmful to the storage tanks. The heavy metal concentrations are high in summer and minima in rainy season due to dilution.

As: the concentration of arsenic in our samples range from 0,08 mg/L for discharges of Cotontchad in July 2013, and 0,78 mg/L for discharges of Brewery of Moundou, ant the value of 0,517 mg/L for discharges of Central Abattoir. All this concentrations are higher than recommended limit by World Health Organization (WHO) of 0,01mg/L. The physico-chemical parameters showed the negative impact of abattoir, brewery and Cotontchad effluents on Logone River water thus rendering the water of worthless value to humans.

Mn: The element manganese is present in over 100 common salts and mineral complexes that are widely distributed in rocks, in soils and on the floors of lakes and oceans. Industrial emissions containing manganese oxides are the principal source of manganese in the atmosphere.In the present study the Mn concentration in industrial effluents ranged from 0.0034 mg/l for discharges of the Brewery of Moundou in December to 0.060 mg/L for effluents of Central Abattoir of all the threeseasons. All values were ender the recommended limit submitted by WHO witch is 0.4 mg/l. Manganese is an essential element in humans and animals, functioning both as an enzyme co-factor and as a constituent of metalloenzymes. Gross deficiencies of manganese have never been observed in the general population, but a recent experimental study involving human subjects fed a manganese-deficient diet (0.11 mg/d) resulted in the development of dermatitis and hypercholesterolemia and elevated concentrations of serum calcium and phosphorus. A statistical analysis of the metabolic studies showed that a daily manganese intake of approximately 5 mg is required to consistently maintain a positive balance.

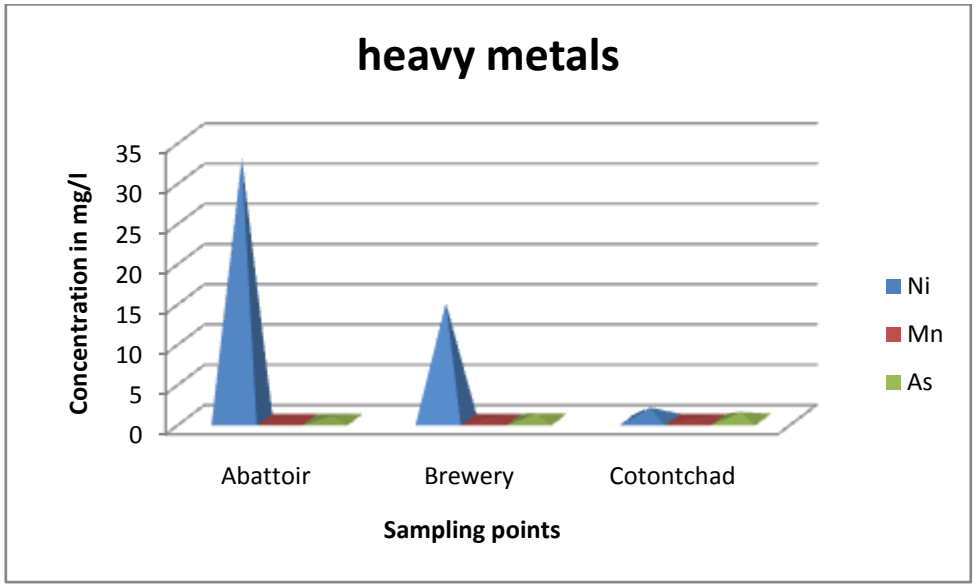

Figure. 5: Average level of Ni, Mn, and As in industrial effluents in Moundou

Hence the abattoir, brewery and Cotontchad urgently need an effluent treatment facility to be installed to reduce the health hazard.

IV. Conclusion

There is no doubt that the pollution generated by Brewery,abattoir, and Cotontchad factory effluents are a clear evidence that the beer, meat and soap/oil processingindustry in Moundou city south of Chad has a potential for generatinglarge quantities of effluent with high physicochemical parameters, like oxygendemand (COD) which would worsen scarcity of cleanwater availability to the generality of the population. The high pH value (12,60) for discharges of Cotontchad, and (11,5) for Brewery could affect the fauna and flora of Logone river living . The heavy metals verification as reported above indicate that there is significant difference in the concentration of the pollutants taken from different sampling points. The result shows a higher concentration of heavy metals such as: Fe, Cu, Zn, Cd, Cr, Pb, Mn, Al released of Fe by the Abattoir (63.34 mg/L) then for the Cotontchad (62 mg/L) and finally for the Brewery with a concentration of 8.40mg/L. Regarding the BOD, the Cotontchad effluents comes in first with a concentration of 1070 mg/L, followed by Brewery with a concentration of 626 mg/L and lastly the Abattoir with 614 mg/L.

The COD concentration obtained in this study 1200 mg/L in the discharges of the Cotontchadwere higher than what was obtained by ALAO Olajumoke*and al*., 2010 in Ibadan, Nigeria. It also higher than COD of Bafoussam Brewery obtained by C.Gouafo and B.P.K. Yerima., 2012.The discharge area of Cotontchad is noted for bad odor practically at midday caused by the high level of BOD and COD.We conclude that because of the phenomenon of bioaccumulation of heavy metals in the environment and their integration in the food chain, the most polluting industry based on our results is the Abattoir, followed the Cotontchad; the Brewery occupies the last position. Our recommendations are that:

Each industry must implement a wastewater treatment plant adapted to its specific Wastewater. The Cotontchad factory should establish a plant capable of purifying: Fe, Cu, Pb, Zn, Cr, phosphorus and organic nitrogen. The Abattoirshould be able to purify: Fe, Cu, Zn, As, and organic nitrogen. Finally, the Brewery should establish a water treatment plant capable of purifying: Cu, Cr, Fe, Pb, As, phosphorus and organic nitrogen. In addition to the treatment plants, wastewater recycling in the manufacturing circuit before sending to the treatment plant would achieve zero pollution status regarding the following metals: Fe, Cu Zn, Cr, and Pb, for Cotontchad; reducing temperature and Cr, Fe, Pb, As, Cd and Al for Brewery and Fe, Zn, Cu, As and Al for the Abattoir.

The municipality should bring sponsors of industries to raise awareness on the impact of pollution on the environment and human health. Penalties for pollution should be proportional to the degree of pollution, and to apply the Principe of polluter payer; this would encourage sponsors to fight against pollution.

RECOMMENDATIONS

- Further research on the methods of manufacture of the Cotontchad factory and the Brewery of Moundou, with the aim of determining the causes of the differences in concentrations in pollutants between soap and beer factories.

- Determine the impact of the effluents from the Cotontchad, Abattoir and Brewery on the surrounding water (Logone River) and soils.
- The Municipal community is also advised to institute sensitization meetings with the promoters of these industries on proper wastewater handling and treatment. Penalties for pollution should be proportional to the degree of pollution.

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