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CHARACTERIZATION OF TREATED WASTEWATER REUSED FOR AGRICULTURE IN THE VEGETABLE FARMING AREA OF SEBKHA IN NOUAKCHOTT, MAURITANIA

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ABSTRACT

The study assessed the microbiological and physicochemical parameters of wastewater collected between October 2011 and September 2012 from the effluent of the WWTP in vegetable farming area of Sebkha in Nouakchott.
The results of physicochemical analysis presented in this work have shown those the values of pH varied from 7.3 to 8. The EC values of experimental samples varied from 1050 to 1650 µS/cm. The turbidity values of experimental samples varied from 26.5 to 51.2 NTU. Effluents from the WWTP are characterized by a maximum iron and manganese content respectively of 412 µg/L and 22 µg/L and a minimum of 210 µg/L and 4 µg/L. Effluents from the WWTP are characterized by a maximum ammonia and orthophosphates content respectively of 120 mg/L and 60 mg/L and a minimum of 10 mg/L and 13.8 mg/L. The values of COD recorded at the WWTP effluent ranged from 25 mg/L and 75 mg/L. The microbiological results show that the microbial load of fecal coliforms and fecal streptococci is very important. The levels of fecal coliforms and fecal streptococci ranged respectively between 3.10^3 to 8.10^3 CFU/100 mL and from 5.10^3 to 9.10^3 CFU/100 mL. The microbiological analysis revealed high concentrations of faecal coliforms and faecal streptococci, values exceeding the microbiological standards of the WHO.
The application of Principal Component Analysis indicates that two groups of wastewater: a group of wastewater turbid characterized by a mineral salt, some metals and organic and inorganic matter expressed by COD and a group

of wastewater consists of very high levels of fecal loads, ammonium and phosphates.

Keywords: Characterization, wastewater, Sebkha, Nouakchott, Mauritania.

RESUME

L'étude concerne l'évaluation de la qualité physicochimique et microbiologique des eaux usées collectées au niveau des effluents de la STEP du périmètre maraicher du Sebkha à Nouakchott, entre Octobre 2011 et Septembre 2012.
Les résultants de l'analyse physicochimique présenté dans ce travail a montré des valeurs de pH ont varié entre7.3 à 8. La conductivité électrique a varié entre1050 à 1650 µS/cm. Les effluents de la STEP sont caractérisés par un maximum en fer et en manganèse contenant respectivement 412 µg/L et 22 µg/L et un minimum de 210 µg/L et 4 µg/L. Les effluents de la STEP sont caractérisés par un maximum en ammonium et en orthophosphates contenant respectivement de 120 mg/L et 60 mg/L et un minimum 10 mg/L and 13.8 mg/L. Les valeurs de la Demande Chimique en Oxygène a oscillé de 25 mg/L à 75 mg/L. Les résultats microbiologiques monte que la charge en Coliformes Fécaux et les Streptocoques Fécaux est très importante. Les teneurs en Coliformes Fécaux et Streptocoques Fécaux a varié respectivement de 3.10^3 à 8.10^3 UFC/100 mL et de 5.10^3 à 9.10^3 UFC/100 mL. L'analyse microbiologique a révélé des teneurs très importantes en Coliformes Fécaux et Streptocoques Fécaux, des teneurs dépassant les normes de l'OMS.
L'application de l'Analyse en Composantes Principales indique deux groups d'eau usée: un groupe d'eau usée caractérisé par une turbidité, des sels minéraux exprimés par la conductivité électrique, quelques métaux et des matières organiques et inorganiques exprimés par DCO et un groupe d'eau usée constituée par des charges fécales, ammoniacales et phosphatées.

Mots clés : Caractérisation, eau usée, Sebkha, Nouakchott, Mauritanie.

INTRODUCTION

The use of wastewater in agriculture is a centuries-old practice. Consequence of rapid urbanization and higher volumes rejected the use of wastewater for irrigation on a large scale, was presented as an alternative to circumvent the problem of water (Mario and Boland, 1999).
The scope of market-garden Sebkha has been the subject of several studies. The microbiological testing of water and soil, hydrogeological studies in the dry season and rainy season to assess the potential water, studies on agricultural technology and farming practices and irrigation studies were

carried out on the market-garden of Sebkha (Azandosessi et al., 1999; Cissé and Tanner, 2000). The main objective is to characterize the quality of effluent from the WWTP (Waste Water Treatment Plant) of market-garden Sebkha with using PCA (Principal Component Analysis) coupled the physicochemical and microbiological parameters. This method is widely used to interpret the hydrochemical data (Bennasser, 1997; El Mohrit et al., 2008).

MATERIAL AND METHODS

Study of area

The study area is the city of Nouakchott, in the coastal region with about 18° 07 North latitude and 16° 01 West longitude as shown in Figure 1. Nouakchott is located in the southern part of Sebkha Ndramcha directly opposite a supply flush and its level is directly related to that of the Atlantic Ocean (Mint El Bezeid, 2006).

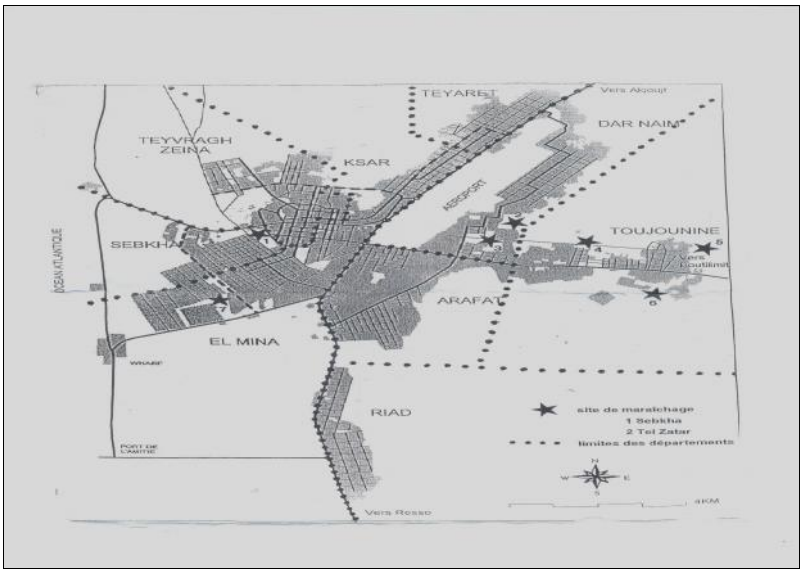

Figure 1 : Map of Localization of Nouakchott City

Some industrial units also connected to the WWTP (Society for a Bottling Company and a specialized fishing in the area Sales cephalopods). The sampling site is where all the raw sewage drained from some of the city of Nouakchott. This wastewater is transported to the WWTP. The rest of the population uses pit latrines, septic tanks or has no drainage system at all. The city of Nouakchott benefits only 4% from its sewage waste.

Sampling and Analysis

Monthly samplings were made at the WWTP between October 2011 and September 2012. The wastewater samples were collected manually in Polyethylene Bottles, capacity 1 liter. The analyses were carried out immediately after sampling in the Laboratory of Water Chemistry of National Institute for Research in Public Health in Nouakchott.
The parameters studied are: potential of Hydrogen (pH), Electrical Conductivity (EC), Turbidity, iron (Fe), Manganese (Mn), ammonia (NH_4^+), orthophosphates (PO_4^{3-}), Chemical Oxygen Demand (COD), Fecal Coliform (FC) and Fecal Streptococci (FS). The pH and EC are measured in situ. The pH was determined by a Wagtech pH meter. The EC was measured by Wagtech Conductimeter. The turbidity was measure by Wagtech Conductimeter. The COD was determined with a HACH DR 5000 Spectrophotometer from dilutions of the samples analyzed. Ammonium, orthophosphates, iron and manganese were measured by a Wagtech Photometer 7100 with pastilles. For the enumeration of FC and FS the technique of membrane filtration through a ramp filter was used. The culture medium used for FC is Tergitol 7 and enumeration of colonies was done after 24 h incubation at 44°C. The isolation of FS is done by the same method but on the culture medium (Slanetz agar) incubated at 37°C for 24 to 48 h. The results are expressed as Colony Forming Unit per 100 mL (CFU/100 mL).
In order to establish a relationship between physicochemical and microbiological parameters from the effluent of the WWTP in vegetable farming area of Sebkha in Nouakchott, a statistical PCA was applied to all parameters between October 2011 and September 2012. The PCA aims to present graphically the maximum information in a data table, based on the principle of double projection on the factorial axis. This statistical method allows to transform the initial quantitative variables, all more or less correlated with one another, new quantitative variables, uncorrelated, called principal components (Davis, 1984). The Statistical study was based on the PCA. The correlation between the variables and factors and the projection of spatially variable axes F1 and F2 were obtained with XLSTAT 2012 Software.

RESULTS AND DISCUSSION

Table 1 showed the maximum, minimum, average and standard deviations of the physicochemical and microbiological parameters such as pH, EC, turbidity, NH_4^+, PO_4^{3-}, COD, Fe, Mn, FS and FC recorded from samples taken between October 2011 and September 2012.

Table 1: Results of the effluent from the WWTP

Variable	Minimum	Maximum	Mean	Standard Deviation
pH	7,3	8	7,7	0.16
EC (µS/cm)	1050	1650	1365,5	183.2
Turbidity (NTU)	26,5	51,2	37,9	8.9
COD (mg/L)	25	75	48.5	12.5
$\mathbf{PO_4^{3-}}$ (mg/L)	13,8	60	32,9	15.9
$\mathbf{NH_4^+}$ (mg/L)	10	120	43,3	36.7
Fe (µg/L)	210	412	314,2	75.2
Mn (µg/L)	4	22	12,6	6.13
FC (CFU / 100 mL)	3.10^3	8.10^3	6.10^3	1592
FS (CFU / 100 mL)	5.10^3	$9.\ 10^3$	7.10^3	1284

The values of pH varied from 7.3 to 8 with an average of 7.7 shown in Table 1, which indicates that the treated municipal wastewater is slightly alkaline in nature. The normal pH range for irrigation water is from 6.5 to 8.4. Irrigation water with a pH outside the normal range may cause a nutritional imbalance or may contain a toxic ion (Ayers and Westcott, 1985).

The EC) is the most important parameter in determining the suitability of water for irrigation use and it is a good measurement of salinity hazard to crop. The most important negative effect on the environment caused by agricultural wastewater is the increases in soil salinity, which if not controlled, can decrease productivity in long term (WHO, 2005). The primary effect of high EC reduces the osmotic activity of plants and thus interferes with the absorption of water and nutrients from the soil (Tatawat and Singh, 2008). The EC values of experimental samples varied from 1050 to 1650 µS/cm (mean value = 1365.5 µS/cm) (Table 1).

The turbidity measurement is a parameter convincing in many cases of applications: the treatment of drinking water and wastewater. Turbidity of water is a global measure that takes into consideration all colloidal materials, insoluble, organic or mineral origin. Turbidity is representative of the transparency of water. Transparency can be affected by the presence of suspended particles and colloidal matter in water (silt, clay, microorganisms, etc...). (Marechal et al, 2011). The turbidity values of experimental samples varied from 26.5 to 51.2 NTU (mean value = 37.2 NTU) (Table 1).

COD can appreciate the concentrations of organic or inorganic, dissolved or suspended in water, through the amount of oxygen necessary for their total chemical oxidation. It is representative of most of the organic compounds but also oxidizable inorganic salts (sulfides, chlorides, etc..) (Rodier, 1996). The values of COD recorded at the WWTP effluent ranged

from 25 mg/L and 75 mg/L. The average value of COD is obtained from 48.5 mg/L (Table 1). The average values of COD are well above 500 mg/L, considered as a limiting value of direct discharge (Ministry of Environment of Morocco, 2002).

The presence of Fe in water can promote the proliferation of certain strains of bacteria that precipitate iron which corrodes pipes. The presence of Fe in water beyond 0.1 mg/L is troublesome because it will give the water a yellow to orange, cause deposits of ferric hydroxide, give the water an unpleasant metallic taste and stain clothing (Hem, 1972; Oliver and Cosgrove, 1975; James, 1977). Effluents from the WWTP are characterized by a maximum iron content of 412 mg/L and a minimum content of 210 mg/L with an average of 314.2 µg/L (Table 1). The iron content recorded in the effluent from the city of Nouakchott is less than 5 mg/L considered to limit water for irrigation (Ministry of Environment of Morocco, 2002).

Mn is an element of low toxicity having considerable biological significance and one of the more biogeochemical and active transition metals in aquatic environment (Evans et al, 1977). Effluents from the WWTP are characterized by a maximum Mn content of 22 µg/L and a minimum content of 4 µg/L with an average of 12.6 µg/L (Table 1).

The ammonia derived from the degradation of animal protein (nitrogen cycle), domestic effluents (urea) and urban runoff (Udert et al., 2003). Effluents from the WWTP are characterized by a maximum ammonia content of 120 mg/L and a minimum content of 10 mg/L with an average of 43.3 µg/L (Table 1).

The majority of organic phosphorus from the waste of protein metabolism and elimination in the form of phosphates in the urine by humans (Du Chaufour, 1997). The maximum value in orthophosphate in the effluent of the WWTP is 60 mg/L and the mean minimum of 13.8 mg/L with an average of 32.9 mg/L (Table 1). The levels of orthophosphate recorded at the WWTP are lower than 10 mg/L considered as an acceptable limit of a direct discharge to the receiving environment (Ministry of Environment of Morocco, 2002).

Bacterial parameters which serve as indicators of fecal pollution are also very important when human are the prime concern. The specific identification of pathogenic bacteria is extremely difficult; the coliform group of organisms is used as an indicator of its presence in wastewater organisms. Coliform bacteria are found in intestinal tract of human beings. Coliform group of bacteria include genera Escherichia and Aerobatic. In the effluent of the WWTP, the microbial load of FC and FS is very important. The levels of FC and FS ranged respectively between 3.10^3 to 8.10^3 CFU/100 mL and from 5.10^3 CFU/100 mL to 9.10^3 CFU/100 mL (Table 1). These values are lower to those found in municipal effluents in Dakar (Niang, 1996). Also, the bacterial load level that is recommended by WHO for irrigation water is 10^3 CFU / 100 mL (WHO, 1994).

Data obtained from physicochemical and microbiological parameters for PCA, using variables such as pH, EC, turbidity, ammonium, orthophosphates, Fe, Mn, COD, FC and FS and from samples taken between October 2011 and September 2012 were processed (Table 2 and Figure 2).

Table 2: Correlation between the variables and factors

	F1	**F2**
pH	-0,439	-0,079
EC	0,905	0,168
Turbidity	0,727	-0,081
COD	0,785	-0,263
PO_4^{3-}	0,145	0,917
NH_4^+	-0,071	0,891
Fe	0,887	0,211
Mn	0,910	0,195
FC	-0,337	0,205
FS	-0,353	0,339

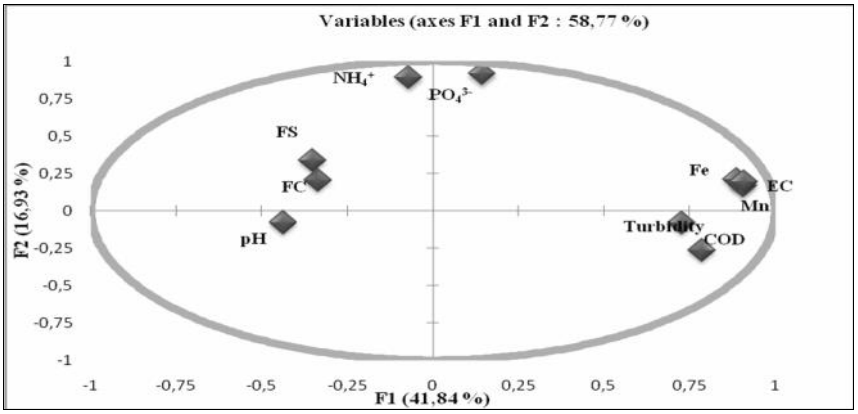

Figure 2: Projection of spatially variable axes F1 and F2

The factorial analysis of F1 and F2 shows that more than 58.77 % are expressed. The axis F1 has a variance equal to 41.84 % and it consists EC, turbidity, COD, Fe, Mn and pH negatively (Table 2 and Figure 2). The F1 axis corresponds to a turbid wastewater content a mineral salt, some metals and organic and inorganic matter expressed by COD. The F2 axis has a variance of 16.93 % and is expressed by the orthophosphates, ammonia, FC and FS (Table 2 and Figure 2). The axis F2 corresponds to a group of wastewater rich in fecal load, ammonium and orthophosphate.

N'Diaye et al, (2009) report on the physicochemical characterization of raw sewage from the City of Nouakchott showed that domestic discharges consist mainly of ammonium and orthophosphate and only the industrial units connected to the sewerage system are responsible for the salinity and mineralization of the effluent from the City of Nouakchott. We can say the F1 axis is typical of wastewater from industrial effluents and the axis F2 is typical of wastewater from domestic effluents.

CONCLUSION

The study of the physicochemical quality of the WWTP effluent on vegetable in Sebkha show the all parameters studied. Bacteriological pollution levels recorded at the effluent from the City of Nouakchott in the irrigated perimeter gardener Sebkha are higher than the recommended by WHO. The presence of very high indicator organisms of fecal contamination is undoubtedly a threat to market gardeners, children of farmers, retailers and consumers. The application of the PCA on these results gave overall, two groups: a group of waste water turbid characterized by wastewater content a mineral salt, some metals and organic and inorganic matter expressed by COD and a group of wastewater consists of very high levels of fecal loads, ammonium and phosphates.
The introduction of Legislation for wastewater Management in Mauritania and the generalization of the sewerage in all City of Nouakchott will avoid any form of Environmental Pollution.

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