

Research Paper

Characterization of the quality of treated wastewater from the Wastewater Treatment Plant (WWTP) effluent in Sebkh, Nouakchott, Mauritania

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ABSTRACT

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The study aimed to analyze the physicochemical parameters and microbiological assessment of effluent from WWTP on vegetable in Sebkh. The results of physicochemical analysis presented in this work showed that wastewater temperatures were 28.7°C. The pH varies between 7.4 and 7.9. The salinity of the effluent was observed by measuring the electrical conductivity and chlorides with respective maximum values of 3290 $\mu\text{S}/\text{cm}$ and 1262.1 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 between 1.5×10^4 ufc/100 mL to 2.7×10^4 ufc/100 mL and 1.8×10^4 ufc/100 mL to 3×10^4 ufc/100 mL respectively. 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 Principal Component Analysis indicates that two groups of wastewater: a group of waste water from largely industrial effluents characterized by high alkalinity and high salinity and another from domestic effluents consists of very high levels of fecal loads and ammonium phosphates.

Key words: Characterization, physicochemical, microbiological, effluent, Sebkh, Nouakchott, Mauritania.

INTRODUCTION

The usage of urban and suburban wastewater that has undergone treatment is growing rapidly and become a fundamental policy of integrated water management in large cities. The benefits obtained are numerous, for example reducing demand for potable water that can reach 10 to 15%, 40% in residential areas with lots of green space. The most common uses are irrigation of green spaces viz parks, golf courses and sports fields, landscaping viz waterfalls, fountains and ponds, washing vehicles or streets and protection against fire outbreak. The standards governing the quality of wastewater for such purposes are very severe and similar to those applicable to drinking water. Thus, many guidelines have been developed to provide a quality treated wastewater and advice on how it must be reused for irrigation (WHO, 2003).

The scope of the market-garden of Sebkh has been the subject of several studies. The microbiological and physicochemical testing of water on agricultural and irrigation studies were carried out on the market-garden of Sebkh (Cissé and Tanner, 2000; N'diaye et al., 2009; N'diaye et al., 2010). Thus, the present investigation was conducted to study the physicochemical and microbiological quality of the WWTP effluent for agricultural use (vegetable garden)

MATERIALS AND METHODS

The study area

The study area is the city of Nouakchott, in the coastal

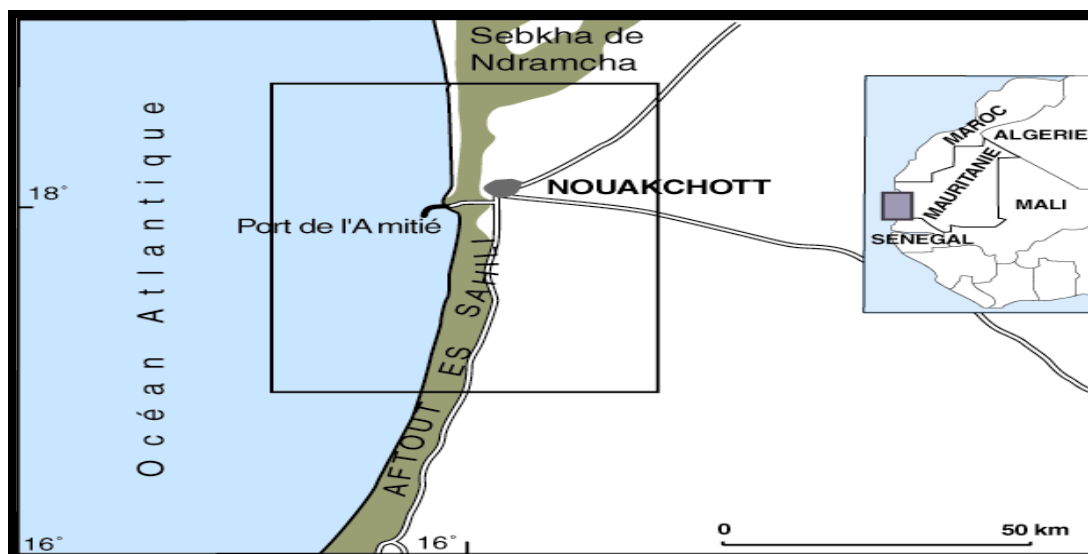


Figure 1. The map of localisation of Nouakchott city.

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 Sebkhia Ndrancha directly opposite a subpy flush and its level is directly related to that of the Atlantic Ocean. Nouakchott is supplied with drinking water from the well field of Idini, located on the road of hope about 60 km from the city (Mint El Bezeid, 2006). The sampling site is where all the raw sewage drained from some of the city of Nouakchott. This wastewater is transported to the WWTP. Industrial units are also connected to the WWTP e. g a bottling company and a sales cephalopods (specialized in fishing). The rest of the population uses pit latrines, pits and cesspools, septic tanks or has no drainage system at all (STUDI, 2000). The city of Nouakchott benefits only 4% from its sewage waste.

Sampling and analysis

Bimonthly samplings were made at the WWTP during February 2008 to December 2009. 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 INRSP (National Institute for Research in Public Health) in Nouakchott.

The parameters studied are: temperature (**T**), potential of hydrogen (**pH**), electrical conductivity (**EC**), chloride (**Cl⁻**), ammonia (**NH₄⁺**), orthophosphates (**PO₄³⁻**), chemical oxygen demand (**COD**), fecal coliform (**FC**) and streptococci coliform (**FS**). The temperature, pH and electrical conductivity are measured *in situ*. The pH and temperature were determined by a pH meter (Hanna HI 9024 type) equipped with a probe measuring the temperature. The electrical conductivity was measured by a Hanna HI 8733 type. The chlorides are measured by volumetric method of

Mohr in the presence of silver nitrate (Rodier, 1996). Orthophosphates and ammonium were determined by UV visible spectrophotometer type 722 S Beijing. Ammonia was analyzed by the colorimetric method in the presence of Nessler reagent. For the determination of orthophosphate, molybdic reagent was used. The COD was determined with a HACH DR 5000 spectrophotometer from dilutions of the samples analyzed. For the enumeration of fecal coliforms and fecal streptococci the technique of membrane filtration through a ramp filter was used. The culture medium used for fecal coliforms is Tergitol 7 and enumeration of colonies was done after 24 h incubation at 44°C. The isolation of fecal streptococci 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 (ufc/100 mL).

In order to establish a relationship between physicochemical and microbiological parameters and quality of the WWTP effluent perimeter of Sebkhia gardener, a statistical PCA (Principal Component Analysis) was applied to all parameters between February and December 2009. 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 2010 Software.

RESULTS AND DISCUSSION

Table 1 showed the maximum, minimum, average and

Table 1. Physico-chemical and microbiological results of the effluent from the WWTP.

Parameter	Maximum	Minimum	Mean	Standard deviation
T (° C)	28,7	26,3	27,8	2,6
pH	7,9	7,4	7,6	0,45
EC (μS/cm)	3290	1510	2340	610
Cl ⁻ (mg/L)	1262,1	682,7	950,1	328,4
NH ₄ ⁺ (mg/L)	92,6	65,1	75,8	13,3
PO ₄ ³⁻ (mg/L)	20,01	14,10	18,2	12,21
COD (mg/L)	561,8	378,8	466,1	74,1
FC (ufc/100 mL)	2,74.10 ⁴	1,5.10 ⁴	2,5.10 ⁴	3325
FS (ufc/100 mL)	3.10 ⁴	1,8.10 ⁴	2,1.10 ⁴	3389

standard deviations of the physicochemical and microbiological parameters such as temperature, pH, electrical conductivity, chlorides, ammonium, orthophosphates, chemical oxygen demand, fecal coliform and fecal streptococci recorded from samples taken between February 2008 and December 2009.

Temperature

The water temperature is an ecological factor that has important ecological repercussions (LEYNAUD, 1968). It acts on the density, viscosity, gas solubility in water, the dissociation of dissolved salts, as well as the chemical and biochemical reactions, development and growth of organisms living in water and especially microorganisms (WHO, 1987). The average values of temperature recorded oscillate between 26.3 and 28.7°C (Table 1). The recorded temperatures are below 35°C considered limiting value of direct discharge into the receiving environment (Ministry of Environment of Morocco, 2002).

pH

This is the concentration of H⁺ in the water. It summarizes the stability of the balance between the different forms of carbonic acid and is related to the buffer system developed by carbonates and bicarbonates (HIMMI et al., 2003). The mean values of pH of the effluent of the WWTP ranged from 7.4 to 7.9 (Table 1). The pH values ranged from near neutral to basic values.

Electrical conductivity

The electrical conductivity is probably one of the simplest and most important for the quality control of wastewater. It reflects the overall degree of mineralization, it tells us about the salinity. The Electrical Conductivity 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 electrical conductivity values of experimental samples varied from 1510 to 3290 μS^{cm}⁻¹ (mean value = 2340 μS^{cm}⁻¹) (Table 1). These results could be explained by the release of waste water from industrial units connected to the WWTP. The average values of conductivity recorded at the effluent of the WWTP is slightly closer to 2700 μS^{cm}⁻¹ (Ministry of Environment of Morocco, 2002).

Chlorides

The chlorides are important inorganic anions contained in varying concentrations in natural waters, usually in the form of sodium salts (NaCl) and potassium (KCl). They are often used as an index of pollution. They have an influence on the aquatic fauna and flora as well as plant growth. The most common toxicity is from chloride (Cl⁻) in the irrigation water. The chloride is not adsorbed or held back by soils, therefore it moves readily with the soil-water, is taken up by the crop, moves in the transpiration stream, and accumulates in the leaves. If the chloride concentration in the leaves exceeds the tolerance of the crop, injury symptoms develop such as leaf burn or drying of leaf tissue (Pescod, 1985). The obtained chloride ion concentration of the samples varied from 682.7 to 1262.1 mgL⁻¹ (mean value = 950.1) (Table 1). The drinking water from the city of Nouakchott is characterized by chloride contents ranging from 106.5 and 127.8 mgL⁻¹. This is due to the high chloride content consumed by the fishing company using largely sea water for the treatment of cephalopods. The concentrations found in wastewater from the effluent of WWTP are greatly exceeding the concentration limit for irrigation water (350 mgL⁻¹) (Ministry of Environment of Morocco, 2002).

Ammonia

Ammonia is derived from the degradation of animal protein (nitrogen cycle), domestic effluents (urea) and urban runoff (Udert et al., 2003, Bonte et al., 2008). The maximum value of ammonium in the effluent of the WWTP is 92.6 mgL⁻¹ and

Table 2. Correlation between the variables and factors.

	F1	F2
T	-0,304	0,862
pH	-0,300	0,886
EC	-0,236	0,692
Cl-	-0,649	0,614
COD	-0,801	0,363
PO ₄ ³⁻	0,741	0,603
NH ₄ ⁺	0,829	0,482
FC	0,862	0,476
FS	0,862	0,444

the mean minimum is 65.1 mgL⁻¹ (Table 1). The bottling company and fishing company are characterized by ammonium amount ranging from 0.016 to 1.06 mgL⁻¹ and 21, 96 to 22.80 mgL⁻¹ (Table 2).

Orthophosphates

Majority of organic phosphorus are from the waste of protein metabolism and in the urine of humans in the form of phosphates. Phosphorus is not inherently toxic to wildlife, terrestrial and aquatic flora. "Eutrophication" is the most direct consequence of an excess of phosphorus, a very worrying effects on many levels (Du Chaufour, 1997). The maximum value of orthophosphate in the effluent of the WWTP is 20.1 mgL⁻¹ while the mean minimum is 14.1 mgL⁻¹ (Table 1). The levels of orthophosphate recorded at the WWTP are much lower than 10 mgL⁻¹, this is considered as an acceptable limit of direct discharge to the receiving environment (Ministry of Environment of Morocco, 2002).

Chemical oxygen demand

The COD is a vital test for assessing the quality of effluents and wastewaters prior to discharge. The COD test predicts the oxygen requirement of the effluent and is used for monitoring and control of discharges and for assessing treatment plant performance. Thus, COD is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. The COD is the amount of oxygen consumed by the chemically oxidizable matter in the water. It is a representative of most organic compounds but also oxidizable mineral salts (sulphides, chlorides ...). The COD allows us to appreciate the concentration of organic or inorganic, dissolved or suspended in water, through the amount of oxygen necessary for their total chemical oxidation (Rodier, 1996). The values of COD recorded at the WWTP effluent range from 561.8 and to 378.8 mgL⁻¹ (Table 1). The values of COD recorded in effluent from the city of Nouakchott are slightly greater than 500 mgL⁻¹, considered as direct discharge limit

value (Ministry of Environment of Morocco, 2002).

Fecal coliforms and fecal streptococci

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 *Aerobacter*. In the effluent of the WWTP, the microbial load of fecal coliforms and fecal streptococci is very important. The levels of fecal coliforms and fecal streptococci ranged respectively between 1.5x10⁴ to 2.7x10⁴ cfu/100 mL (Table1) and from 1.8x10⁴ cfu/ to 3x10⁴ cfu/100 mL (Table 1). These values are lower and sometimes comparable to those found in municipal effluents in Dakar (Niang, 1996). Also, the bacterial load level that is recommended by WHO for irrigation water is 10³ cfu / 100 ml (WHO, 1994).

Data obtained from physicochemical and microbiological parameters for PCA, using variables such as temperature, pH, electrical conductivity, chlorides, ammonium, orthophosphates, COD, fecal coliform and fecal streptococci and from samples taken between February 2008 and December 2009 were processed.

The factorial analysis of F1 and F2 shows that more than 81.30% are expressed. The axis F1 has a variance equal to 44.31% and it consists of orthophosphates, ammonium, fecal coliforms and fecal streptococci (Table 2 and Figure 2). The F2 axis has a variance of 36.99% and is expressed by the temperature, pH, electrical conductivity, chlorides and COD that is positive (Table 2 and Figure 2).

The axis F1 corresponds to a group of wastewater rich in fecal load, ammonium and orthophosphate from largely domestic waste, toilets, baths, etc. this group is typical of wastewater from domestic effluents. The F2 axis corresponds to a basic group of wastewater with high salinity and high organic matter expressed as COD. This group is typical of wastewater from industrial effluents.

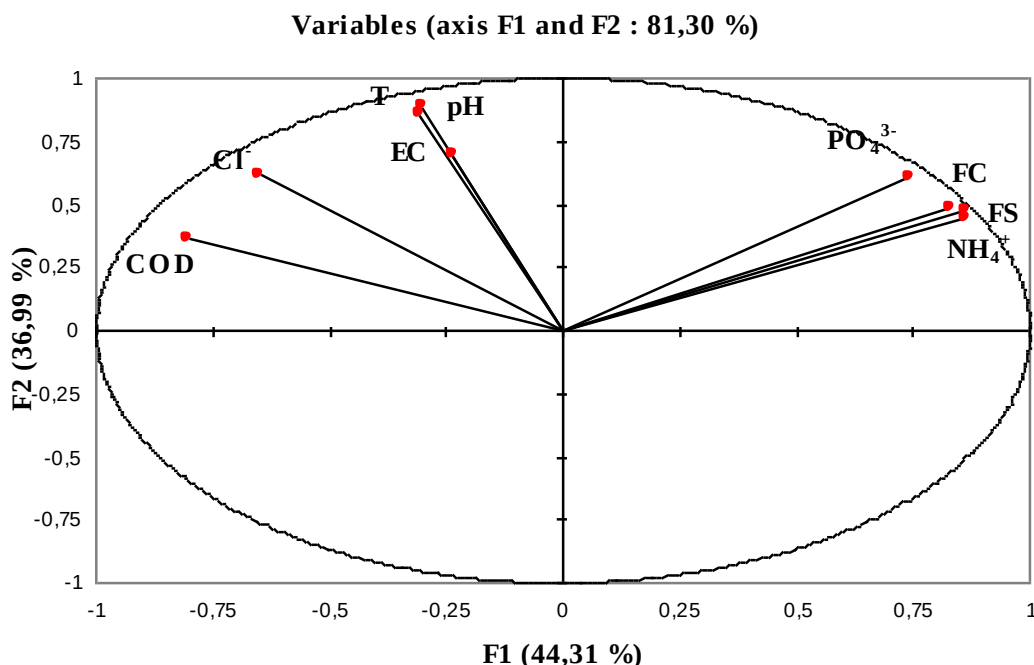


Figure 2. Projection of spatially variable axes F1 and F2.

Work 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 from toilets, etc. and only the industrial units connected to the sewerage system are responsible for the salinity of the effluent from the city of Nouakchott. One can say that there are two types of pollution: salt and organic pollution from industrial plants connected to the sewage and faecal pollution from discharges of some domestic quarters connected to the sewerage of the city.

Conclusion

The study of the physicochemical quality of the WWTP effluent on vegetable in Sebkha show the existence of pollution resulting in high salinity which can have a negative impact on soils and crops of Sebkha gardener. Bacteriological pollution levels recorded at the effluent from the city of Nouakchott in the irrigated perimeter gardener Sebkha are higher than the thresholds 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 Principal Component Analysis on these results gave overall, two groups of wastewater: a group of waste water from largely industrial effluents characterized by high salinity and a group of water from domestic wastewater consists of very high levels of fecal loads, and ammonium phosphates.

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