

# Study of water quality during rainy season using physico-chemical and metallic parameters of Senegal River in Mauritania

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## ABSTRACT

The environmental quality is greatly focused on water because of its importance in maintaining the human health and health of the ecosystem. Study of Rainy Seasonal Physicochemical and metallic parameters in Senegal River in Mauritania was carried out between August and September 2012. The water quality was studied at four sites around Rosso City in Mauritania. The parameters measured include: Temperature (T), pH, Electrical Conductivity (EC), Turbidity, Chloride (Cl<sup>-</sup>), Nitrates (NO<sub>3</sub><sup>-</sup>), Nitrites (NO<sub>2</sub><sup>-</sup>), Ammonia (NH<sub>4</sub><sup>+</sup>), Orthophosphates (PO<sub>4</sub><sup>3-</sup>), Oxidizables Matters (OM), iron (Fe), Manganese (Mn), Zinc (Zn), Cupper (Cu), Aluminium (Al) and lead (Pb). The values of the measured parameters were compared with WHO standards for drinking water quality. The findings show that all the physicochemical and metallic parameters measured were within the tolerable values except turbidity, orthophosphates, nitrites, ammonia, Aluminum and Cupper. The highest levels of turbidity, orthophosphates, nitrites, ammonia Aluminum and Cupper observed in the Senegal River are respectively 346 NTU, 7.9 mg/L, 0.65 mg/L, 1.12 mg/L, We can say that the water from Senegal River is affected by the natural processes during the rainy season as well as anthropogenic influences from domestic wastewater and agricultural activities. Therefore, frequent monitoring of physicochemical parameters of Senegal River water resources is imperative

**Keywords:** Quality, Physicochemical, metallic, Water, River Senegal, Mauritania.

## INTRODUCTION

The quality of surface water provides significant information about the available resources for supporting life in the ecosystem (Manikannan, et al., 2011). The physical, chemical and biological compositions of surface water is controlled by many factors such as natural (precipitation, geology of the watershed, climate and topography) and anthropogenic (domestic, industrial activities and agricultural run-off). Increasing surface water pollution causes not only deterioration of water quality, but also threatens human health, balance of aquatic ecosystem, economic development and social prosperity (Milovanovic, 2007).

Some studies have been conducted on the right bank of the Senegal River in Mauritania (Ould Kankou, 2004; N'Diaye et al., 2013). We are interested now to study of rainy seasonal physicochemical and metallic parameters in Senegal River in Mauritania. It is imperative to prevent and control the surface water pollution and to have reliable information on its quality for effective management

## MATERIAL AND METHODS

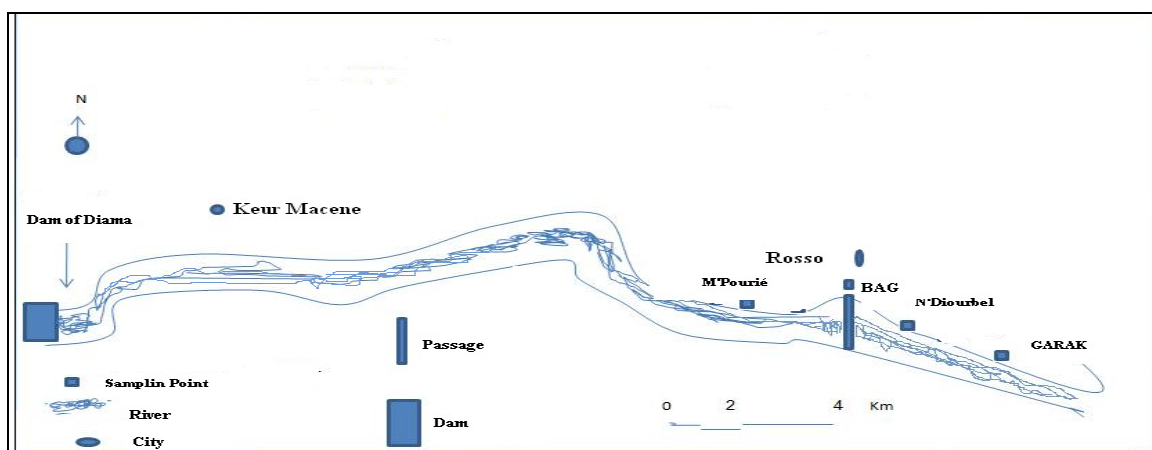
**Study Area:** The Senegal River plays a very important role as the main source of surface water for Mauritania, Senegal and Mali. The river water is used for drinking, fishing, irrigation and other domestic purposes. The Senegal River basin is

located in West Africa. It is drained by the 1800 km long Senegal River, the second longest river of West Africa, and its main tributaries, the Bafing, Bakoye and Faleme Rivers, all three of which have their source in the Fouta Djallon Mountains (Guinea). The river's flow regime depends, for the most part, on rain that falls in the upper basin in Guinea (about 2,000 mm/year). In the valley and the delta, rainfall is generally low and there is rarely more than 500 mm/year. During the drought years of the 1970s, there was significantly less. The climatic regime in the basin can be divided into three seasons: a rainy season, from June to September, a cold-dry off-season, from October to February, and a hot-dry off-season, from March to June. This creates a high-water period or flood stage between July and October and a low-water period between November and May/June (Ould Kankou, 2004).

The Manantali dam, built on the Bafing River, is the largest in the basin. Its purpose is to attenuate extreme floods, generate electric power and store water in the wet season to augment dry season flow for the benefit of irrigation and navigation. The Diama dam, located near the mouth of the Senegal River in the delta, serves to block seawater intrusion and thereby protect water and irrigation wells, and raises the level of the upstream water body, creating reserves to enable irrigation and double cropping (Ould Kankou, 2004).

All field work has been done on the study area on the right bank of the Senegal River. For quantitative analysis of Senegal River water, various samples were collected from the four stations: Bag, N'Diourbel, M'Pourié and Garak (Figure 1).

**Figure 1.** Location on map sampling site



**Samplings and Analytical Determination:** The samples were collected between August and September 2012. The samples were collected in polyethylene bottles with a capacity of 1 liter. The samples were kept in a well refrigerated with thermostat until Laboratory of Water Chemistry, National Institute for Research in Public Health to Nouakchott in Mauritania. The physicochemical parameters studied are Temperature (T), pH, Electrical Conductivity (EC), Turbidity, Chloride ( $\text{Cl}^-$ ), Nitrates ( $\text{NO}_3^-$ ), Nitrites ( $\text{NO}_2^-$ ), Ammonia ( $\text{NH}_4^+$ ), Orthophosphates ( $\text{PO}_4^{3-}$ ), Oxidizables Matters (OM), iron (Fe), Manganese (Mn), Cupper (Cu), Zinc (Zn), Aluminium (Al) and lead (Pb).

The Temperature and pH was measured by a pH meter Wagtech. The electrical conductivity was measured by a conductimeter Wagtech. Turbidity was measured by a turbidity meter Wagtech. The chlorides are measured by volumetric method of Mohr in presence silver nitrate. Nitrates, nitrite, ammonia, Aluminium and Orthophosphates were measured by a photometer DR 5000 with pastilles. The Oxidizables Matters are determined by oxidation in acidic medium with potassium permanganate. Oxidizable matters in the hot water will be oxidized by an excess of  $\text{KMnO}_4$ , which is then reduced by an excess of sodium oxalate which will then titrated with a solution of  $\text{KMnO}_4$ . Fe, Mn, Cu Zn, Al and Pb were determined by Atomic Absorption Spectrophotometer with flame and graphite furnace type PG Instruments 990 controlled by software. Fe, Mn, Cu and Zn by using the flame with air-acetylene. For Pb we used graphite furnace with use of Argon.

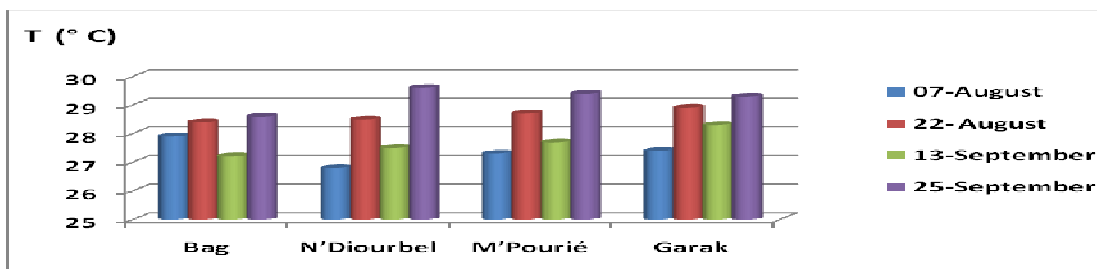
## RESULTS AND DISCUSSION

The results of physico-chemical and metallic analyses of the river Senegal water reveal that the water temperature ranged from a minimum of 26.8 °C at N'Diourbel in August to a maximum of 29.6 °C at N'Diourbel in September (Figure 2).

Temperature is one of the most important ecological features. It controls behavioural characteristics of organisms, solubility of gases and salts in water. The basis of all life functions is complicated set of biochemical reactions that are influenced by physical factors such as temperature. The temperature was basically important for its effects on the

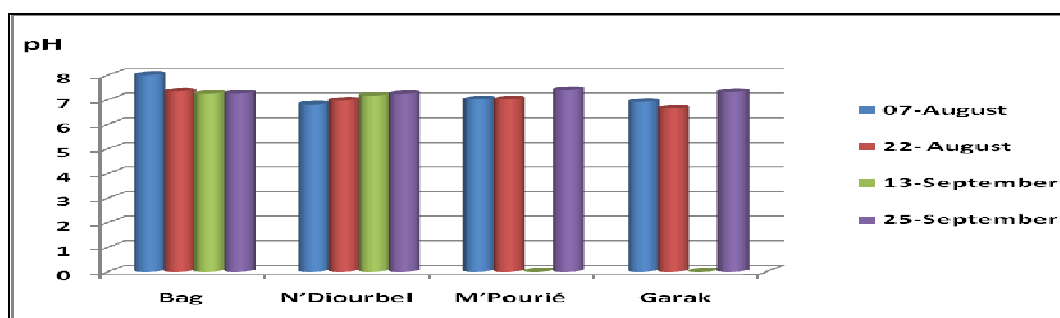
chemistry and biological activities of organisms in water. Temperature was known to influence in the determination of other factors like pH, conductivity, dissolved gases and various forms of alkalinity.

**Figure 2.** Spatial and Temporal variation of Temperature



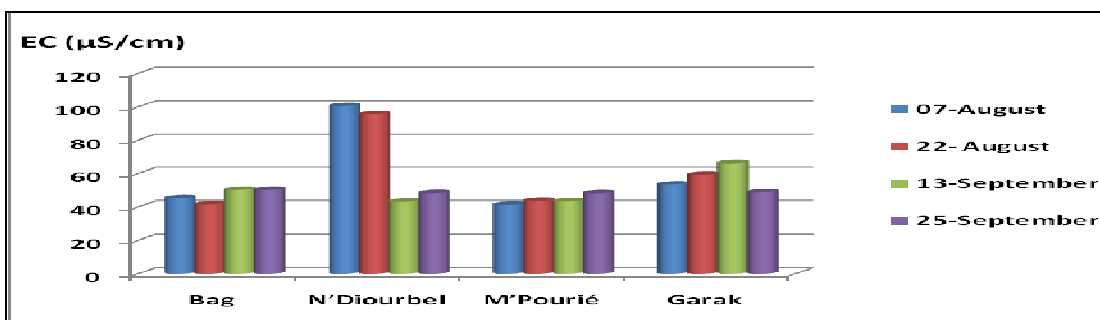
In natural waters, the pH scale runs from 0 to 14. A pH value of 7 is neutral; a pH less than 7 is acidic and greater than 7 represents base saturation or alkalinity. The principal component regulating ion pH in natural waters is the carbonate, which comprises  $\text{CO}_2$ ,  $\text{H}_2\text{CO}_3$  and  $\text{HCO}_3^-$  (APHA, 1995). The pH values of the four sampling points were ranged between 6.82 and 8 (Figure 3). There was no significant difference between the four sampling points. The pH values are within the standards for drinking water quality (WHO, 2006).

**Figure 3.** Spatial and Temporal variation of pH



The electrical conductivity reflects the overall degree of mineralization, it tells us the salinity of the water. This ability depends on the presence of ions; on their total concentration, mobility, and valence; and on the temperature of measurement. The results of physico-chemical and metallic analyses of the river Senegal water reveal that the water electrical conductivity ranged from a minimum of 41.4  $\mu\text{S}/\text{cm}$  at M'Pourié in August to a maximum of 100.5  $\mu\text{S}/\text{cm}$  at N'Diourbel in August (Figure 4). The electrical conductivity values are within the standards for drinking water quality (WHO, 2006).

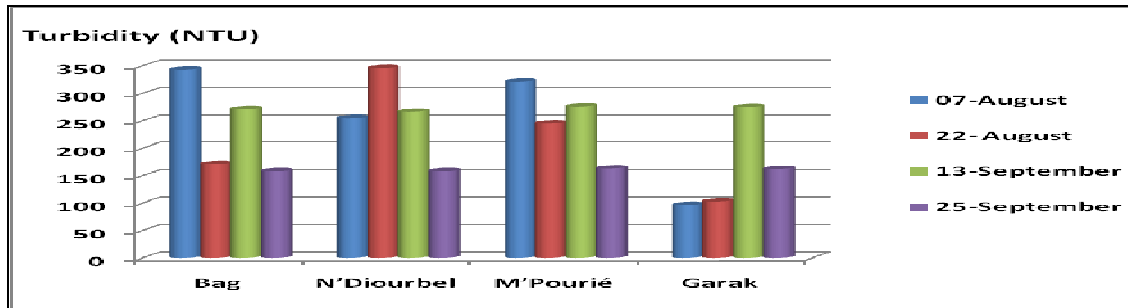
**Figure 4.** Spatial and Temporal variation of EC



Turbidity values varied from a minimum of 96.5 NTU at Garak in August to a maximum of 346 NTU at N'Diourbel in August (Figure 5). The turbidity values obtained for all the locations were higher than WHO standard limit of 5 NTU (WHO, 2006). The clarity of natural body of water is an important determinant of its condition and productivity. Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and

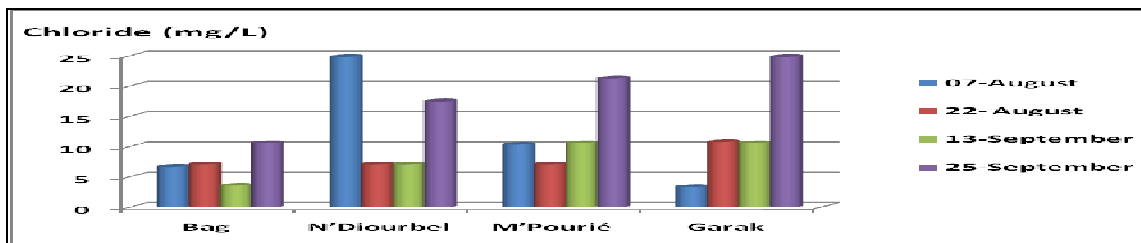
inorganic matter, and plankton and other microscopic organisms (DWAF, 1998).

**Figure 5.** Spatial and Temporal variation of Turbidity



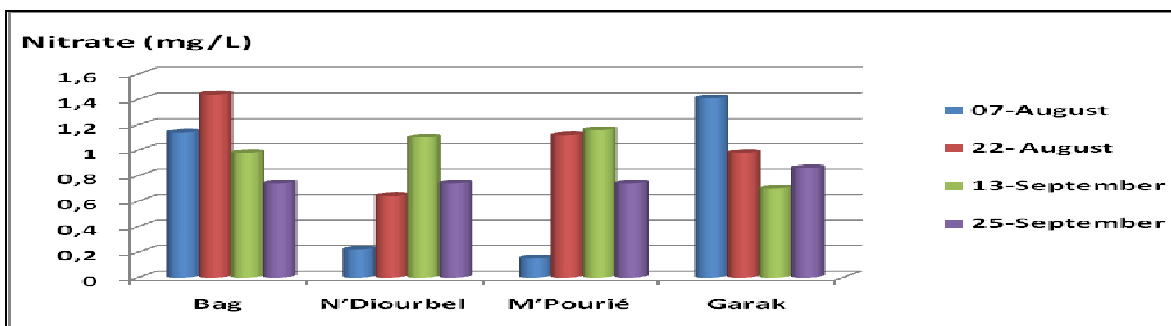
The chlorides values varied from a minimum of 3.55 mg/L at Garak and Bag in August to a maximum of 24.85 mg/L at Grak in September (Figure 6). The results indicate that the chloride content is bottom acceptable limit of 200 mg/L (WHO, 2006). The chlorides are important inorganic anions contained in varying concentrations in natural waters, usually in the form of sodium salts (NaCl). Chloride in excess (> 250 mg/L) imparts a salty taste to water and people who are not accustomed to high chlorides may be subjected to laxative effects. High concentration of chlorides is considered to be the indicators of pollution due to organic wastes of animal or industrial origin. Excessive chloride in potable water is not particularly harmful and the criteria set for this anion are based primarily on palatability and its potentially high corrosiveness (Bhujangaiah and Nayak, 2005).

**Figure 6.** Spatial and Temporal variation of Chloride



Nitrate levels over 10 mg/L in natural waters normally indicate man made pollution. Man made sources of include, fertilizers, livestock, urban runoff, septic tanks and waste water discharges. As more land is converted into agricultural land and as urban areas expand, nitrate monitoring is an important tool in accessing locating and mitigating man made sources of nitrate. Man made sources of nitrate in the environment include domestic and industrial discharges, agricultural runoff where fertilizers. Nitrates values varied from 0.15 mg/L at M'Pourié in August to 1.41 mg/L in August (Garak) (Figure 7). The nitrates values of the different sites of Senegal River samples were found a bottom the permissible limit (50 mg/L) (WHO, 2006).

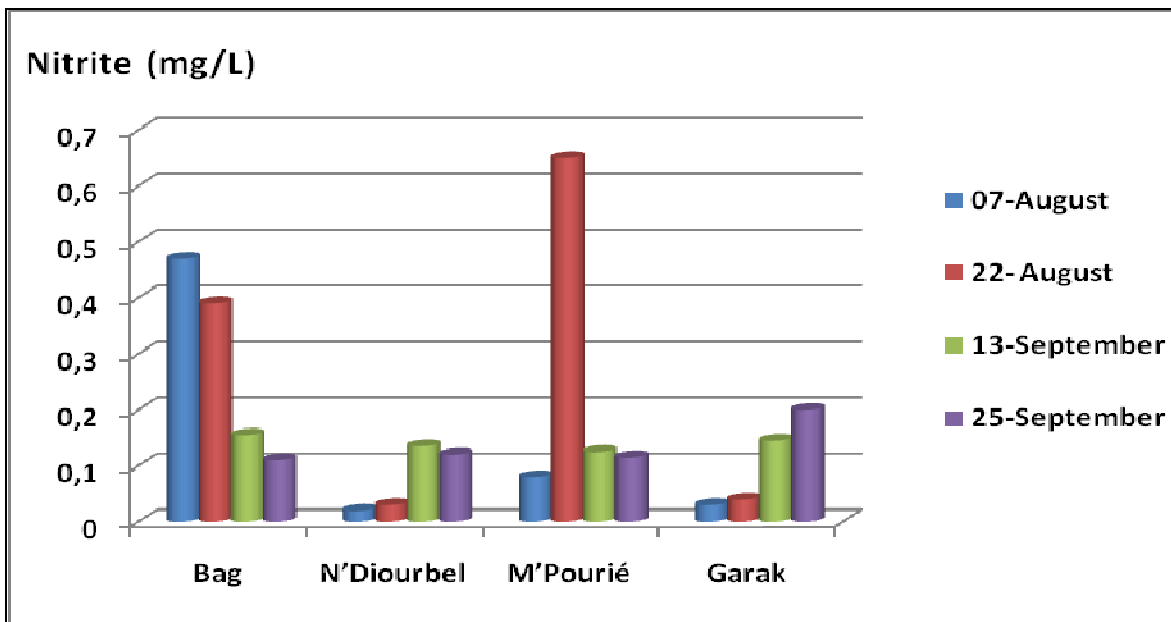
**Figure 7** Spatial and Temporal variation of Nitrate



Nitrites values varied from 0.02 mg/L at N'Diourbel in August to 0.65 mg/L at M'Pourié in August (Figure 8). The maximum nitrites concentration of Senegal river water samples was found to be above the permissible limit (0.2

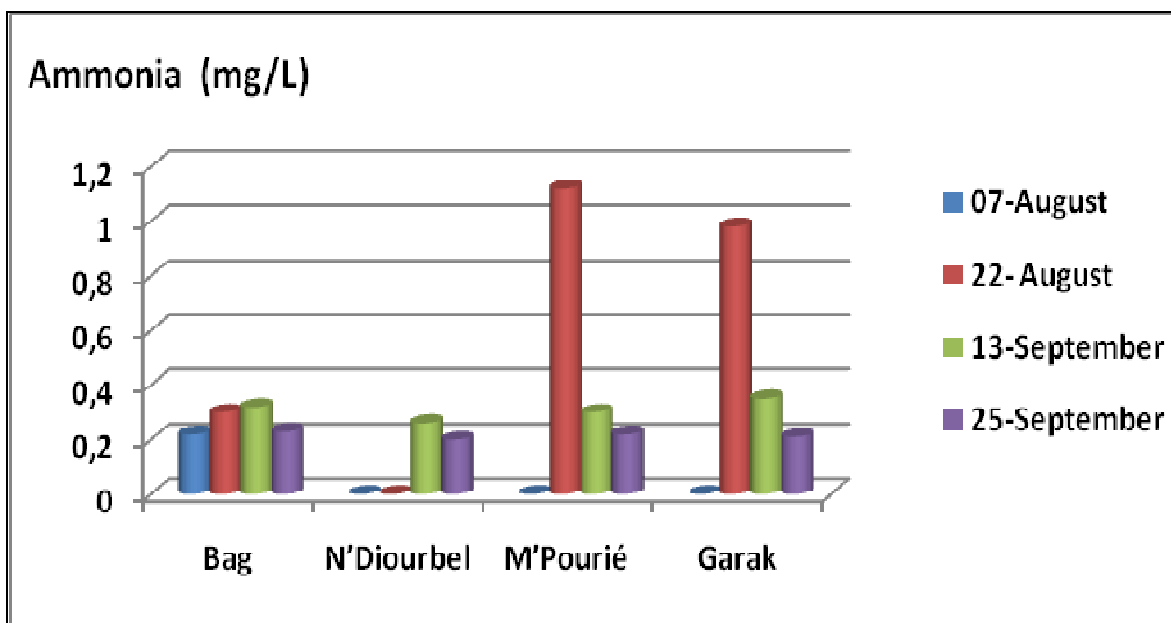
mg/L) (WHO, 2006). The general and health effects of nitrite are to form nitrosamines which are carcinogenic. This was due to the addition nitrogenous nutrients mainly terrestrial runoff like break down of vegetation, use of chemical fertilizers in agriculture and oxidation of ammonia from nitrogen to nitrite (Saravanakumar et al, 2008)

Figure 8. Spatial and Temporal variation of Nitrite



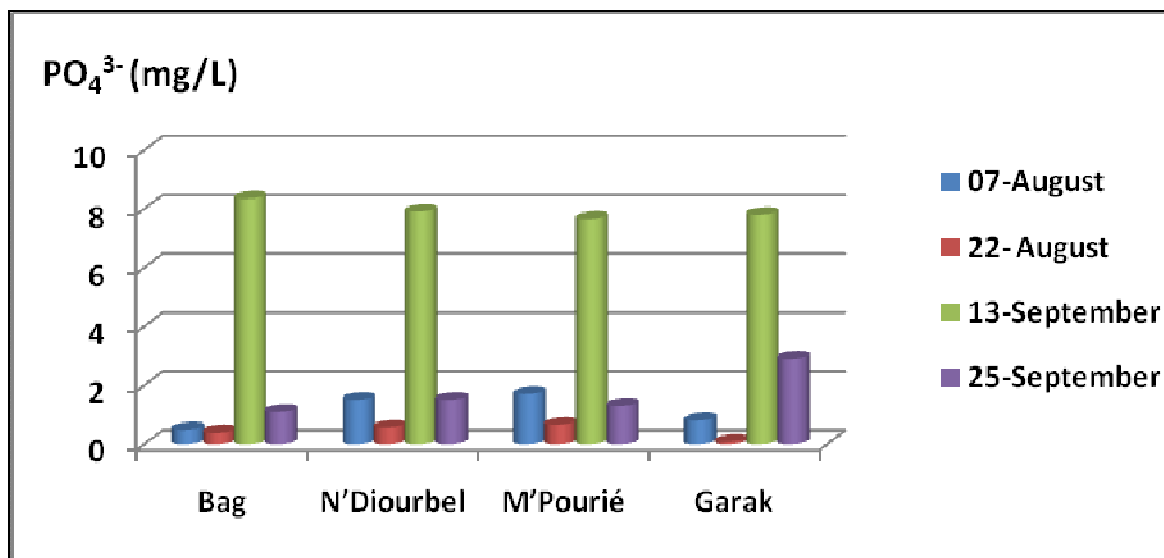
Ammonia values varied from 0 mg/L at N'Diourbel, M'Pourié and Garak in August to 1.12 mg/L at M'Pourié in August (Figure 9). The maximum ammonia concentration of Senegal river water samples was found to be above the permissible limit (0.2 mg/L) (WHO, 2006). Excess ammonia indicates polluted water and maximum algal growth. All proteins contain nitrogen, as do a wide variety of other biomolecules. When metabolized, much of this nitrogen can end up in the form of ammonia (NH<sub>3</sub>). There are bacteria that consume the ammonia and their waste product is nitrite (NO<sub>2</sub>).

Figure 9. Spatial and Temporal variation of Ammonia



The orthophosphates values varied from a minimum of 0.08 mg/L at Garak in August to a maximum of 8.35 mg/L at Bag in August (Figure 10). The maximum phosphate concentration of Senegal river water samples was found to be higher than the permissible limit (0.1 mg/L) (WHO, 2006).

Figure 10. Spatial and Temporal variation of orthophosphate



Maximum level of phosphate was found in the river water where it receives maximum sewage, domestic wastes and human activities. Use of detergent may increase the phosphate concentration to great extent. The anthropogenic additions of phosphorus to the river have a considerable effect on the quality of the water. Such phosphorus is derived mainly from domestic sewage and the runoff from agricultural areas. The quantity of phosphorus in the domestic sewage and land drainage have increased considerably in recent years due to the increased use of synthetic detergents which contain approximately by weight, the inorganic condensed phosphates. The river is used for the washing purposes and the detergents would enhance the load of this element. A higher amount of phosphate represent high pollution loads and causes eutrophication of the aquatic body. The clothes are washed directly into the river or even if they are not washed, the wash water by joining the canals (Figure 11). It is important to note here that the Mauritians have the habit of wearing clothes color and dyeing is done locally in large part most often ignored basic of all products (Ould Kankou, 2004)

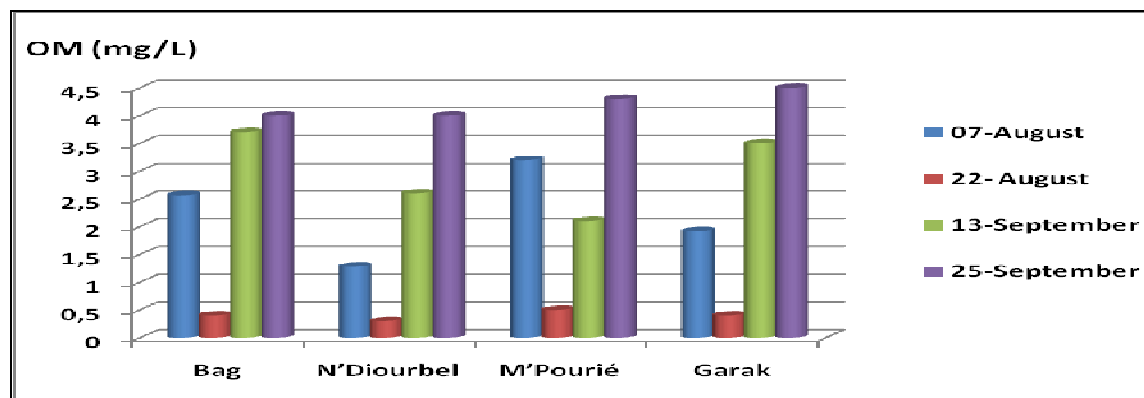
Figure 11. Some activities of washing the clothes along the Senegal River



The OM is representative of the majority of the organic oxidizable compound but also mineral salts (sulphides, chlorides, etc.). In the field of natural organic matter, humic substances, mainly composed of humic and fulvic acids, has a very large share. They are responsible for the color of the water has properties of ion exchangers and complexing properties. They can be a vehicle for the most toxic substances (heavy metals, pesticides ...) (Ayele et al, 1993). OM values varied from 0.3 mg/L (N'Diourbel) to 4.5 mg/L (Garak) (Figure 12). The OM values of the different sites of river water samples were found is below the acceptable limit of standards for drinking water (5 mg/L) (WHO, 2006)



Figure 12. Spatial and Temporal variation of OM



Metals come from industry, agriculture (irrigation with polluted water use of mineral fertilizers, pesticides containing heavy metals) and urban wastewater (Azimi et al, 2005). The important contribution of pollution in the Senegal River is the result of the discharge of wastewater from the town of Rosso in particular leaching uncontrolled garbage in the river (Figure 13).

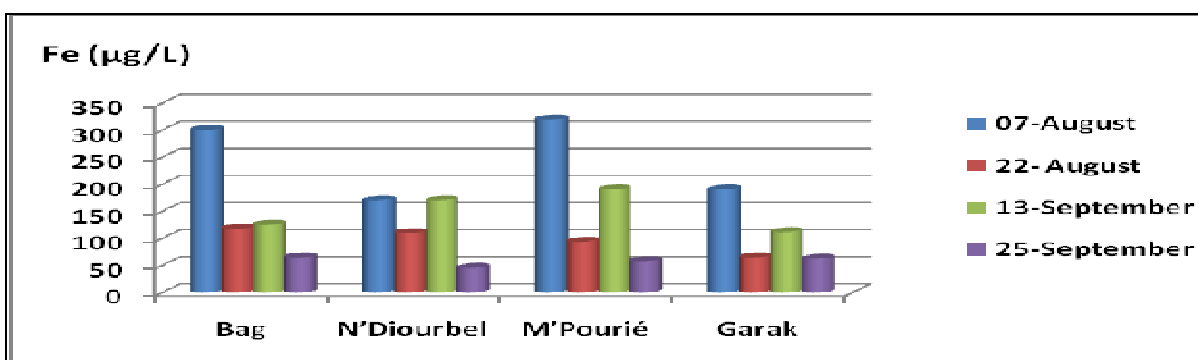
Figure 13. Along the right bank of the Senegal River



The Fe values varied from 45  $\mu\text{g/L}$  at N'Diourbel in September to 300  $\mu\text{g/L}$  at M'Pourié in August (Figure 14). The presence of Fe may increase the hazard of pathogenic organisms; since most of these organisms need Fe for their growth (Tiwana et al, 2005). The Fe values of the different sites of river water samples were found a lower the permissible limit of standards for drinking water (500  $\mu\text{g/L}$ ) (WHO, 2006).

Most ferrous compounds in aquatic environments are resulting from the precipitation of Fe in alkaline and oxidizing conditions (Abdulla et al. 1973). Most Fe is found as different forms of Fe oxides like hematite, magnetite, and taconite (Edwards, 2010). Another reason for the increase in Fe content might be de to the run off from domestic wastes and other urban wastes (Neal et al., 2000).

Figure 14. Spatial and Temporal variation of Fe

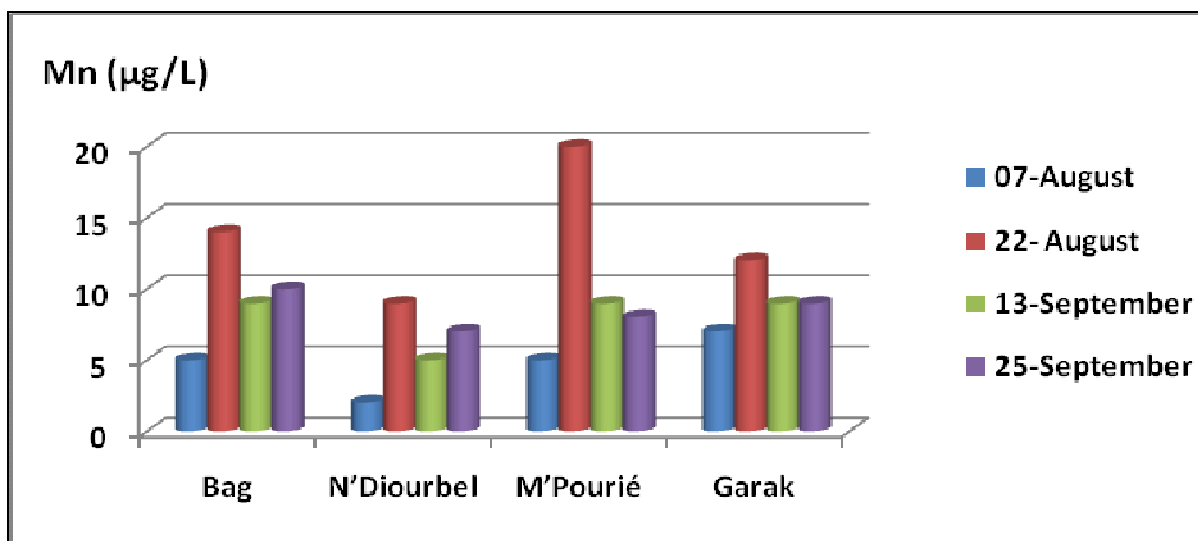


The Mn values varied from 2  $\mu\text{g/L}$  at N'Diourbel in August to 20  $\mu\text{g/L}$  at M'Pourié in August (Figure 15). Mn is an element of low toxicity having considerable biological significance and one of the more biogeochemical and active transition metals in aquatic environment (Evans et al, 1977). The Mn values of the different sites of river water

samples were found a lower the permissible limit of standards for drinking water (400  $\mu\text{g/L}$ ) (WHO, 2006).

The higher Mn concentrations might be due to the addition of sewage and domestic wastes in the river (Neal et al, 2000)

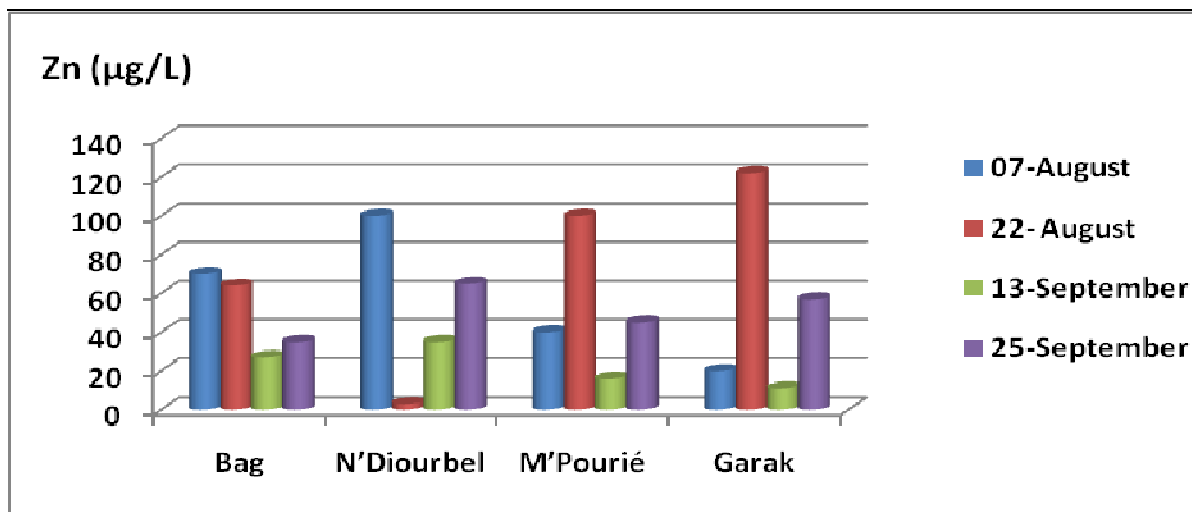
**Figure 15.** Spatial and Temporal variation of Mn



The Zn values varied from 3  $\mu\text{g/L}$  at N'Diourbel in August to 122  $\mu\text{g/L}$  at Garak in August (Figure 16). Zn is an enzyme co-factor in several enzyme systems including carbonic anhydrase found in red blood cells. The Zn values of the different sites of river water samples were found a lower the permissible limit of (standards for drinking water (1000  $\mu\text{g/L}$ ) (WHO, 2006).

Zn is naturally found in air, water, and soil. Zn concentrations are rising due to additions of Zn to the environment industrial activities like mining, coal, waste combustion, and steel processing (Edwards, 2010)

**Figure 16.** Spatial and Temporal variation of Zn

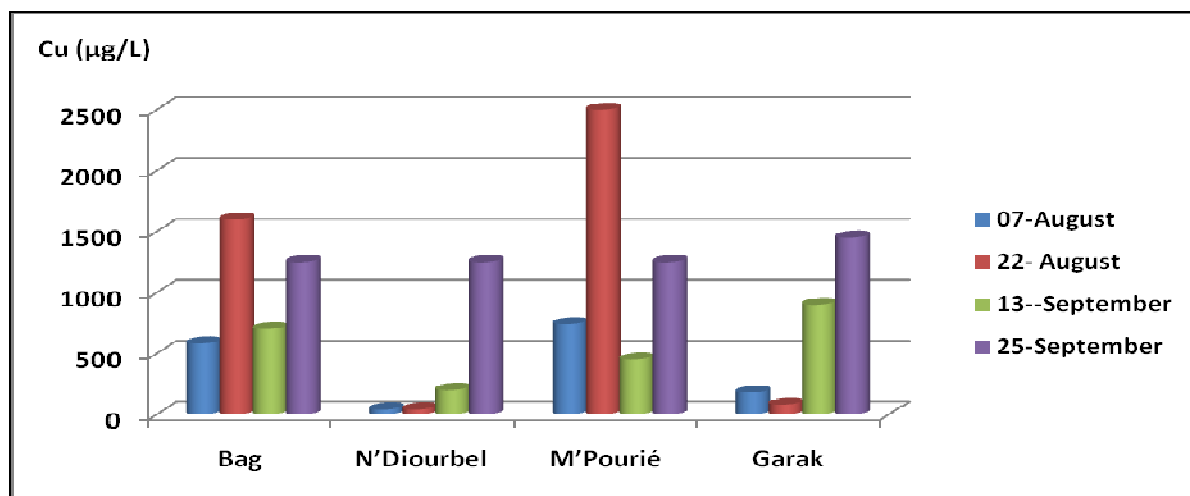


The Cu values varied from N'Diourbel 40  $\mu\text{g/L}$  at M'Pourié in August to 2500  $\mu\text{g/L}$  at M'Pourié in August (Figure 17). Copper is a necessary nutrient for human health. However, Cu in high doses results in anemia, liver and kidney damage, and stomach and intestinal irritation (Edwards, 2010). The observed maximal values were higher than the permissible limit of 2000  $\mu\text{g/L}$  set by WHO (WHO, 2006).

Copper is used in electrical wiring as it is easily worked and can be drawn into fine wire and has high electrical conductivity (Edwards, 2010). Copper is used in industries and in agriculture. Copper also enters the air, mostly through the release during the combustion of fossil fuels (Edwards, 2010). The higher Cu concentrations might be due to the addition of sewage and domestic wastes in the river (Neal et al, 2000)

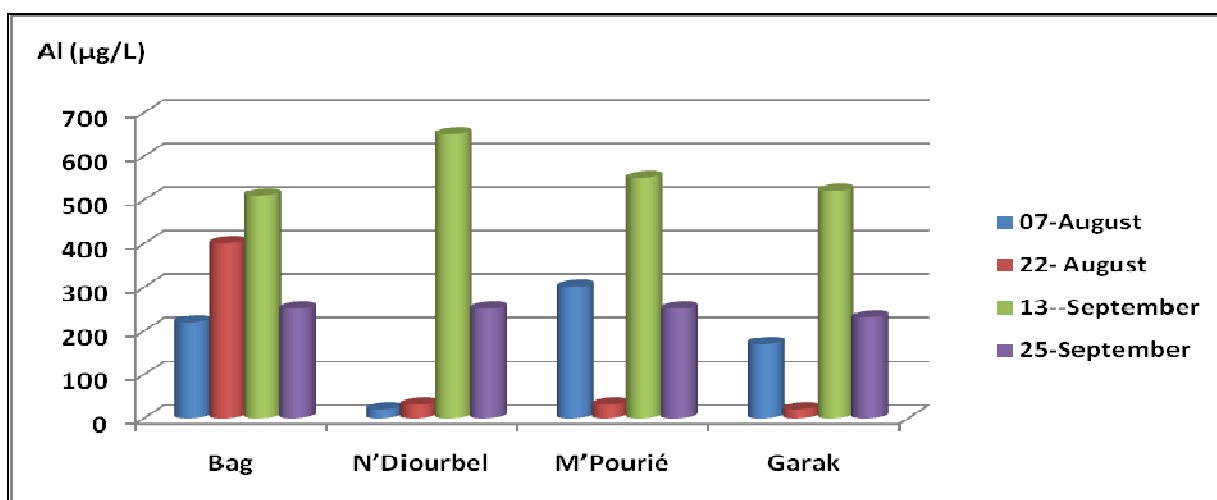


Figure 17. Spatial and Temporal variation of Cu



The Al values varied from 20 µg/L at Garak in August to 650 µg/L at N'Diourbel in September (Figure 18). However, the World Health Organization (WHO, 1998) concluded that, although there were studies that demonstrate a positive relationship between aluminum in drinking water and Alzheimer's disease, the WHO had reservations about a causal relationship because the studies did not account for total aluminum intake from all possible sources. The Al values of the different sites of river water samples were found a lower the permissible limit of standards for drinking water is 200 µg/L (WHO, 2006). The sources of Al in fresh water include domestic wastes, manufacturing processes involving metals, and the dumped sewage sludge (James 1991)

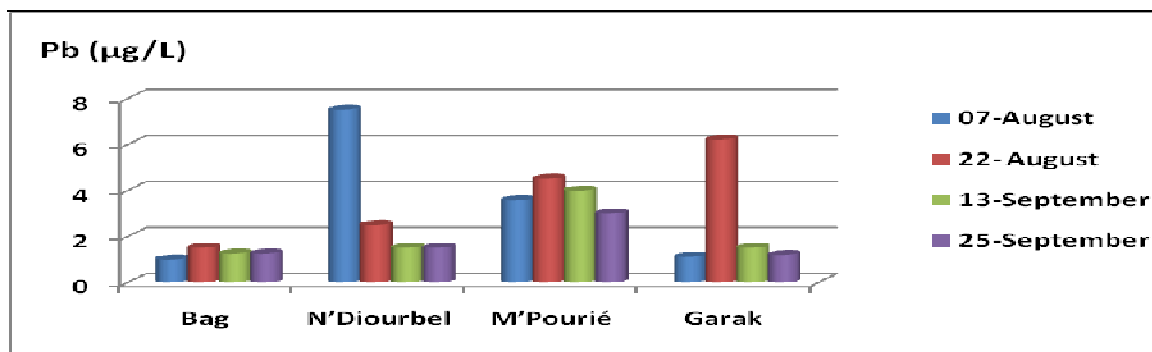
Figure 18. Spatial and Temporal variation of Al



The Pb values varied from 1 µg/L at Bag in August to 6.2 µg/L at Garak in August (Figure 19). The Pb values of the different sites of river water samples were found a below the permissible limit of standards for drinking water is 10 µg/L (WHO, 2006). Pb is a very dangerous heavy metal for humans. Illnesses from high lead concentrations are disruption of the biosynthesis of hemoglobin and anemia. Other health risks linked to lead are a rise in blood pressure, kidney damage, miscarriages and subtle abortions, disruption of nervous system, brain damage, declined fertility of men through sperm damage, diminished learning abilities in children, and behavioral disruptions in children like aggression, impulsive behavior, and hyperactivity (Edwards, 2010).

Pb is one of the oldest metals known to man and is discharged in the surface water through paints, solders, pipes, building material, gasoline etc. Pb is a well known metal toxicant and it is gradually being phased out of the materials that human beings regularly use. Combustion of oil and gasoline account for > 50% of all anthropogenic emissions, and thus form a major component of the global cycle of Pb. Atmospheric fallout is usually the most important source of Pb in the freshwaters (Moore et Ramamoorthy, 1984).

Figure 19. Spatial and Temporal variation Pb



## CONCLUSION

The water from Senegal River showed high values of turbidity, nitrate, nitrite, ammonia, orthophosphate, Aluminium and Copper it is affected by the natural processes such as erosion of minerals and dissolution of nutrients from the rocks during the rainy season as well as anthropogenic influences from domestic wastewater and agricultural activities. It is time for national authorities to develop a network of quality control of the Senegal River in setting up sensors to continuously monitor the concentrations of DO, turbidity, temperature, pH, conductivity, nitrates, etc.

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