Water quality assessment of Senegal River in Mauritania by turbidity and chemical parameters analysis during rainy season

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This study was carried out to assess the water quality of the Senegal River by turbidity and Chemical parameters during the rainy season. The 24 samples were collected from 4 stations and sampling was conducted at two different dates, namely 7th and 22nd August 2013. The chemical parameters studied are Ammonia (NH₄⁺), Orthophosphates (PO₄³⁻), Silica (SiO₂), Oxidizables Matters (OM), Aluminium (Al), iron (Fe), Manganese (Mn), Zinc (Zn) and lead (Pb). The water of Senegal River showed the existence of the pollution from the turbidity during August; corresponding at rainy season. Analysis observation revealed variation in the values of NH₄⁺ from 0.01-1.12 mg/L, PO₄³⁻ from 0.49-1.70 mg/L, SiO₂ from 0.04-1.02 mg/L, OM from 1.28-3.84 mg/L, Al from 20-500 µg/L, Fe from 170-320 µg/L, Mn from 1-6 µg/L, Zn from 20-100 µg/L and Pb from 0.5-10.2 µg/L. The use of turbidimetry for assessing water pollution is positive and motivating by its permanence, instantaneous but not sufficient. It is imperative to study the pesticides content in the water of Senegal River to make a good model of treatment.

Key words: Principal component analysis, chemical, water, River Senegal, Mauritania.

INTRODUCTION

In most developing countries, control and monitoring of the quality of surface waters used for the production of drinking water are not systematic lack of means. From the scientific point of view, environmental monitoring campaigns produce large amounts of data that are often not easy to interpret (Kowaliski et al., 2006; Felipe-Sotelo, 2007).

In this context, the use of PCA (Principal Component Analysis) for the interpretation of the data seems an interesting solution to a better understanding of water quality and ecological status of the media studied (Simenov et al., 2003). This technique also has the advantage of identifying and linking the various factors (sources) to the observed effects on aquatic systems. It is a best tool for managing water resources to find quick solutions to pollution problems (Ouyang, 2005; Shrestha and Karza, 2007; Mencio and Mas-Pia, 2008). This method is widely used to interpret the hydro chemical data (Bennasser, 1997; El Mohrit et al., 2008).

Few studies have been conducted on the right bank of the Senegal River in Mauritania (Ould Kankou, 2004; Ould Mohameddou, 2006; Mint Mohamed Salem, 2011). The present study is to monitor and assess the turbidity in water from the right bank of the Senegal River using PCA coupled with the turbidity and the chemical parameters.

MATERIAL AND METHODS

Study area

The delta of Senegal River is located in the Sahelian climate zone. This area is characterized by a single rainy season, which extends from July to September with an average annual rainfall of about 250 mm. The rains are often poorly distributed, irregular and generally low. Consequently, they are ineffective for rain-fed agriculture. High temperatures (20°C to over 40°C) and steady winds (harmattan) during
Table 1. The values of chemical parameters of Senegal River water

<table>
<thead>
<tr>
<th>Variables</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM (mg/L)</td>
<td>1.28</td>
<td>3.84</td>
<td>2.79</td>
<td>0.89</td>
</tr>
<tr>
<td>NH$_4^+$ (mg/L)</td>
<td>0.01</td>
<td>0.22</td>
<td>0.05</td>
<td>0.08</td>
</tr>
<tr>
<td>PO$_4^{3-}$ (mg/L)</td>
<td>0.49</td>
<td>1.70</td>
<td>0.99</td>
<td>0.47</td>
</tr>
<tr>
<td>SiO$_2$ (mg/L)</td>
<td>0.04</td>
<td>1.02</td>
<td>0.31</td>
<td>0.36</td>
</tr>
<tr>
<td>Zn (µg/L)</td>
<td>20</td>
<td>100</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Pb (µg/L)</td>
<td>0.5</td>
<td>10.20</td>
<td>2.76</td>
<td>4.23</td>
</tr>
<tr>
<td>Mn (µg/L)</td>
<td>1.00</td>
<td>6.00</td>
<td>2.88</td>
<td>2.41</td>
</tr>
<tr>
<td>Fe (µg/L)</td>
<td>170</td>
<td>320</td>
<td>24.625</td>
<td>56.04</td>
</tr>
<tr>
<td>Al (µg/L)</td>
<td>20</td>
<td>500</td>
<td>220</td>
<td>180</td>
</tr>
<tr>
<td>Cu (µg/L)</td>
<td>75</td>
<td>740</td>
<td>310</td>
<td>296</td>
</tr>
</tbody>
</table>

Figure 1. Location on map sampling site

The dry season result in very high evapotranspiration (up to 1 cm/day) (Ould, 2004). The Senegal River plays a very important role as the main source of surface water for Mauritania, Senegal and Mali. This river is used for drinking, fishing, irrigation and other domestic purposes. This river has a length of 1800 km and crosses four mentioned countries to arrive at Diama Mauritania (Ould, 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).

Samplings and analytical determination

The samples were collected in August 2012. The samples were collected in polyethylene bottles with a capacity of 1 litre. The samples were well refrigerated in thermostat at laboratory of Water Chemistry, National Institute for Research in Public Health Nouakhchott in Mauritania. The physicochemical parameters studied are Turbidity, Ammonia (NH$_4^+$), Orthophosphates (PO$_4^{3-}$), Silica (SiO$_2$), Oxidizables Matters (OM), Aluminium (Al), Iron (Fe), Manganese (Mn), Cupper (Cu), Zinc (Zn) and lead (Pb).

Turbidity was measured by a turbidity meter Wagtech. Ammonia, Silica, Aluminium and Orthophosphates were measured by a photometer DR 5000 with pastilles. The Oxidizables matters were determined by oxidation in acidic medium with potassium permanganate. Oxidizable matters in hot water will be oxidized by an excess of KMnO$_4$, which is then reduced by an excess of sodium oxalate, and titrated with a solution of KMnO$_4$. Fe, Mn, Zn, Cu and Pb were determined using Atomic Absorption Spectrophotometer PG 990, controlled by software with flame and graphite furnace. Fe, Mn, Cu and Zn were determined using the flame with air-acetylene, while Pb was determined using graphite furnace with use of Argon.
Statistical analysis was based on the PCA. Intermediate correlation matrix was obtained with XLSTAT 2012 Software. In order to establish a relationship between turbidity and chemical parameters, the PCA statistical treatment was applied to all parameters (variables) studied. For the treatment of data by PCA, the study used 10 variables such as turbidity, OM, NH\textsubscript{4}, PO\textsubscript{4}, S\textsubscript{i}O\textsubscript{2}, Al, Fe, Zn, Cu, Mn and Pb and as the two samplings (two factors) during the month of August 2012.

**RESULTS AND DISCUSSION**

Turbidity values varied from a minimum of 96.5 NTU at Garak to a maximum of 346 NTU at Bag in 7\textsuperscript{th} August (Figure 2). Turbidity values varied from a minimum of 102.3 NTU at Garak to a maximum of 346 NTU at N'Diourbel as at 22\textsuperscript{th} August (Figure 2). The turbidity values obtained for all the locations were higher than WHO standard limit of 5 NTU (WHO, 2004).

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 (Maréchal et al., 2001; Santé Canada, 2003). High turbid waters are associated with microbial contamination (DWAF, 1998; McCoy and Olson, 1998).

The OM is representative of the majority of the organic oxidizable compound but also mineral salts (sulphides, chlorides, etc.). OM value varied from 1.28 mg/L to 3.84 mg/L with a mean of 2.79 mg/L (Table 1). The OM value of the different sites of river water samples were found below the acceptable limit standards of drinking water (5 mg/L) (WHO, 2004).

Ammonia value varied from 0.01 mg/L to 1.12 mg/L with a mean of 0.05 mg/L (Table 1). The maximum ammonia concentration of Senegal river water samples was found to be above the permissible limit (0.2 mg/L) (WHO, 2004). Orthophosphates value varied from a minimum of 0.49 mg/L to a maximum of 1.70 mg/L with a mean of 0.99 mg/L (Table 1). The maximum phosphate concentration of Senegal river water samples was found to be above the permissible limit (0.1 mg/L) (WHO, 2004). Silica value varied from a minimum of 0.04 mg/L to a maximum of 1.02 mg/L with a mean of 0.31 mg/L (Table 1).

The Fe value varied from 17.0 µg/L to 320 µg/L with a mean of 246.25 µg/L (Table 1). The Fe value of the different sites of river water samples were found below the permissible limit standards of drinking water (400 µg/L) (WHO, 2004). The presence of high concentration of Fe may increase the hazard of pathogenic organisms; since most of these organisms need Fe for their growth (Tiwana et al., 2005).

The Mn value varied from 1 µg/L to 6 µg/L with a mean of 2.88 µg/L (Table 1). The Mn value of the different sites of river water samples were found below the permissible limit standards of drinking water (400 µg/L) (WHO, 2004). 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., 1997). It occurs in surface waters that are low in oxygen and often does so with Fe. It accumulates in certain species of fish (Uthe and Blish, 1976). A probable source of airborne inorganic Mn pollutant is the combustion of methylcyclopentadienyl manganese tricarbonyl (MMT), particularly in areas of high traffic density (Sierra et al., 1998). Combustion of MMT in hot car engine leads to the emission of manganese phosphates, manganese sulfate and manganese oxides that include manganese tetraoxide as a minor component (WHO, 2004; Zayed, 2001).

The Zn value varied from 20 µg/L to 100 µg/L with a mean of 50 µg/L (Table 1). The Zn value of the different sites of river water samples were found below the permissible limit standards of drinking water (1000 µg/L) (WHO, 2004). Excessive concentration of Zn may result in necrosis, chlorosis and inhibited growth of plants.

The Cu value varied from 75 µg/L to 740 µg/L with a mean of 310 µg/L (Table 1). The observed values were above the permissible limit of 50 µg/L set by WHO (WHO,
Table 2. Intermediate matrix correlations between variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Turbidity</th>
<th>OM</th>
<th>Al</th>
<th>NH$_4^+$</th>
<th>PO$_4^{3-}$</th>
<th>SiO$_2$</th>
<th>Cu</th>
<th>Zn</th>
<th>Pb</th>
<th>Mn</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>OM</td>
<td>0.292</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Al</td>
<td>0.719</td>
<td>0.548</td>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>NH$_4^+$</td>
<td>0.587</td>
<td>0.215</td>
<td>0.721</td>
<td>1</td>
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</tr>
<tr>
<td>PO$_4^{3-}$</td>
<td>0.759</td>
<td>-0.160</td>
<td>0.339</td>
<td>0.138</td>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>SiO$_2$</td>
<td>0.673</td>
<td>0.299</td>
<td>0.661</td>
<td>0.318</td>
<td>0.346</td>
<td>1</td>
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<tr>
<td>Cu</td>
<td>0.715</td>
<td>0.326</td>
<td>0.796</td>
<td>0.658</td>
<td>0.620</td>
<td>0.240</td>
<td>1</td>
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<tr>
<td>Zn</td>
<td>0.485</td>
<td>-0.531</td>
<td>-0.124</td>
<td>0.236</td>
<td>0.514</td>
<td>0.218</td>
<td>-0.010</td>
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<tr>
<td>Pb</td>
<td>0.606</td>
<td>-0.448</td>
<td>0.135</td>
<td>0.534</td>
<td>0.544</td>
<td>0.237</td>
<td>0.265</td>
<td>0.938</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>0.868</td>
<td>0.413</td>
<td>0.751</td>
<td>0.372</td>
<td>0.736</td>
<td>0.718</td>
<td>0.732</td>
<td>0.131</td>
<td>0.229</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>0.619</td>
<td>0.782</td>
<td>0.716</td>
<td>0.493</td>
<td>0.325</td>
<td>0.190</td>
<td>0.800</td>
<td>-0.244</td>
<td>-0.043</td>
<td>0.631</td>
<td>1</td>
</tr>
</tbody>
</table>

The results of the analysis show that turbidity has a positive and significant correlations with physicochemical parameters such as Mn (0.868), PO$_4^{3-}$ (0.759), Al (0.719), Cu (0.715), SiO$_2$ (0.673), Fe (0.619), Pb (0.606), NH$_4^+$ (0.587) and Zn (0.485) (Table 2).

These positive and significant correlations allow us to say that these parameters are governed by the same mechanism or phenomenon that could possibly be leaching during the rainy season. During the rainy season with the phenomenon of runoff, rainwater bring with them mud, plant debris, dead animals, thus making river water very muddy; which contains suspended solids.

Level of phosphate was found in the river water where it receives a sewage, domestic wastes and human activities. Clothes are also washed directly into the river (Figure 3). Level of phosphate was found in the river water where it receives a sewage, domestic wastes and human activities. Clothes are also washed directly into the river (Figure 3). The results of the analysis show that turbidity has a positive and significant correlations with physicochemical parameters such as Mn (0.868), PO$_4^{3-}$ (0.759), Al (0.719), Cu (0.715), SiO$_2$ (0.673), Fe (0.619), Pb (0.606), NH$_4^+$ (0.587) and Zn (0.485) (Table 2).

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Excessive Cu content can cause damage to roots, by attacking the cell membrane and destroying the normal membrane structure; inhibited root growth and formation of numerous short, brownish secondary roots. Cu becomes toxic for organisms when the rate of absorption is greater than the rate of excretion, and as Cu is readily accumulated by plants and animals, it is very important to minimize its level in the waterway.

Lead value varied from 0.5 µg/L to 10.2 µg/L with a mean of 2.76 µg/L (Table 1). The Pb value of the different sites of river water samples were found below the permissible limit standards of drinking water (10 µg/L) (WHO, 2004). Lead is one of the oldest metals known to man and is discharged on the surface water through paints, solders, pipes, building material, gasoline etc. Lead 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 lead. Atmospheric fallout is usually the most important source of lead in the fresh waters (Ayele et al., 1993).

The Al value varied from 20 µg/L to 500 µg/L with a mean of 220 µg/L (Table 1). The Al values of the different sites of river water samples were found beneath the permissible limit standards of drinking water (1000 µg/L (WHO, 2004).

The results of the analysis show that turbidity has a positive and significant correlations with physicochemical parameters such as Mn (0.868), PO$_4^{3-}$ (0.759), Al (0.719), Cu (0.715), SiO$_2$ (0.673), Fe (0.619), Pb (0.606), NH$_4^+$ (0.587) and Zn (0.485) (Table 2). These positive and significant correlations allow us to say that these parameters are governed by the same mechanism or phenomenon that could possibly be leaching during the rainy season. During the rainy season with the phenomenon of runoff, rainwater bring with them mud, plant debris, dead animals, thus making river water very muddy; which contains suspended solids.

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not control absolutely the organic micro pollutants (pesticides). It is imperative to study the pesticides content in the water of Senegal River to make a good model of treatment.

**Conclusion**

The water of Senegal River shows the existence of the pollution from turbidity in August (2013); the resultant pollution correlation between the rainy season and anthropogenic factor. The use of turbidimetry for assessing water pollution is positive and motivating by its permanence, instantaneous but not sufficient. 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 physicochemical parameters and it is imperative to study the pesticides content in the water of Senegal River in order to make a good model of treatment.

**REFERENCES**


Tiwa

