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Assessment of Irrigation Water Quality of the Jega Floodplains and Their Influence on Soil Properties

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Abstract

Quality of agricultural water is greatly influenced by its sources, and this invariably affects the quality of agricultural soils, which in turns affects the quality of the produce that were produced from such soils. Jega floodplains and its surroundings serve as a source of water for both agricultural and domestic uses. Therefore to assess the quality of this water is of paramount important, hence a study was carried out to assess the quality of this water for both agricultural and domestic uses. The results of this study reveals that surface stream water from this floodplain area have high concentration of sodium indicating a sodicity status which is turning the soil within this catchment to be slightly sodic which will greatly affect the quality of the soil for agricultural production, however, all the other parameters tested were within the acceptable limits for both agricultural and domestic uses.

Keywords: Floodplains, Tubewell, Surface stream, Salts, Turbidity, Sodicity.

INTRODUCTION

There is a growing human population in the world over which directly means an increase in food production, whereas food production to feed this growing population is decreasing everyday which can be associated with poor agricultural practices. One means to ameliorate this problem is the use of irrigation practice, however, irrigation is associated with a number of problems ranging from water mis-management, use of poor quality irrigation water as a result of salinity, turbidity and other chemicals constituents that makes irrigation water of low quality for crop production. According to (Beltran et al., 1999), soil degradation is a severe global issue and predominant degradation processes and accelerated soil erosion, depletion of soil organic matter and plant nutrients, decline in soil structure and soil salinization. Soil salinization and water logging are the main threat to sustainability of irrigated agriculture. The global estimates of the already affected irrigated lands vary, but the problem is serious and growing un-abated, (Baltran, et al., 1999), for example, estimated that salt affected land in India is about 7.26 million hectares.

Human induced (secondary salinization) occurs in large scale and small scale irrigation schemes alike. Irrigation agriculture is often implicated as a causes of salinization, because where water containing dissolved salts is used for irrigation, the water is taken up by plants and thereafter, remnants of the salts are left behind in the plant root zone (Hoffman et al., 1980). Although salinization often occurs naturally and not as a consequence of poor irrigation, Van Roojen et al. 2005 noted that the applications of fertilizer and irrigation water continue to add salts to the system.

Salt affected soils and water are part of the geochemical processes. Soluble salts originate from weathering of minerals and rocks, depending on the chemical constituents of the parent rock. Normally, salts move from the weathering sites into the ground water system, moves into streams and lakes and then into the oceans, if rainfall is high as in humid climates, most salts have been transported into oceans or to deep groundwater system. In arid environments, where rainfall is limited, salts are frequently present in the soil. Man can alter these geological processes and create salinity hazards in many ways; including irrigation, mining, processing plants and other activities.

Farmers zeal to increase agricultural production to satisfy the food requirements of the ever-increasing
population through irrigation practices which was considered as the main alternatives for a sustainable agricultural production, makes use of water from a wide range of sources without minding the qualities of that water on either the soils, crops, animals and even the man for whom the production is aimed at satisfying. Therefore, this study is aimed at evaluating the quality of irrigation water sources used by the farmers in the study area and possibly recommends ways through which such water can be used to meet the targeted production level with minimal hazards.

MATERIALS AND METHODS

The research was conducted at Jega floodplains which is at latitude 12° 11' N, longitude 4° 16' E in the Sudan savannah agro-ecological zone. The climate is a semi-arid with an average annual rainfall of about 500-650mm, the relative humidity ranges from 21-47% and 51-92% during the dry and rainy seasons respectively, whereas temperature ranges from 20-30°C during the dry cold season, and 27-41°C during the hot rainy season.

The main sources of water for irrigation at the study area are the tubewell and the surface stream water. A total of six (6) tubewells located at an intervals of 1500m apart were selected for water sampling and a six samples (one from each well) were collected and blended to make a single sample that was used for laboratory analysis, an equal distance was also used for collection of the water samples from the surface stream and also blended to make a single sample. Soils from each water sampling point were collected at two different depth of 0-15cm and 15-30cm, which were later blended to make a composite samples of one sample per depth.

The collected water and soil samples were carefully stored in an appropriate container and taken to laboratory for the routine analysis.

The parameters measured for the water quality were; Electrical conductivity (EC), pH, Ca²⁺, Mg²⁺, Na⁺, K⁺, Boron, Sodium adsorption ratio (SAR), NO₃ and Turbidity. EC was determined by conductivity meter electrode, pH was determined in both water and in 0.01M CaCl₂ using glass electrode meter. Organic carbon was determined by Wet oxidation method of Walkley and Black method as described by Allison (1965). K and Na were determined by flame photometer, while Ca and Mg were determined by atomic absorption spectrometry. CEC was determined by using NH₄OAc (pH 7.0) method (Page et al., 1982). Total Nitrogen was determined by macro-kjeldahl procedure as described by Bremner 1965. Available phosphorous was by Bray 1 method Juo, 1979. Nitrate was determined by cadmium reduction method, Juo, 1979. Boron was determined by Azomethene H- procedure, Juo, 1979. Chloride was determined by Bray 1 method (Bray and Kurtz, 1945).

RESULTS AND DISCUSSIONS

Irrigation water quality for the Jega floodplains

Water pH

The pH of the water as shown in Table 1, has the value ranges from 6.9 for the tubewell and 7.1 for the surface stream water. These values are considered to be safe for irrigation activities when compared with the standard value given by (Vudhivanich, 1998), which shows water whose pH values ranges from 6.5-8.5 are safe for both domestic and agricultural purposes. The results is also within the values as determined by Singh and Tsoho (2000) who finds the pH values for both tubewell and surface water of Kebbi State as 7.5 and 7.3 respectively.

EC and SAR of the water

The EC values for both tubewell and surface stream water as shown in Table 1, were below the critical limit to be considered as a potential threat for irrigation activities as they fall below the limit described as hazard by Vudhivanich, 1998. However, there is a threat of sodicity as the value of Na is higher than the critical limit.

Nitrate and Chlorides values of the water sample

The Nitrate levels in both tubewell and surface stream water were found to be 0.01 mg/l and 0.016mg/l respectively. These levels when compared with the levels considered safe for both domestic and agricultural uses by the WHO, 1998, of 5mg/l, they can be regarded as safe for the same purpose as well. However, due to the mobile nature of N, and considering agricultural activities going on within the study area, addition of nitrogenous fertilizers to the soil can further leads to an increase of the nitrate content in the tubewell water, however, as the area is not an industrial area, less nitrate is expected to goes into the surface stream water.
Table 1. Mean values of EC, pH, Basic cations, Nitrate, Chloride, Boron, SAR and Turbidity of Tubewell and surface stream water of the Jega floodplain.

<table>
<thead>
<tr>
<th>Water source</th>
<th>EC</th>
<th>pH</th>
<th>Ca</th>
<th>Mg</th>
<th>Na</th>
<th>K</th>
<th>NO₃</th>
<th>Cl</th>
<th>B</th>
<th>SAR</th>
<th>Turbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tubewell</td>
<td>244</td>
<td>6.9</td>
<td>1.1</td>
<td>1.7</td>
<td>14</td>
<td>21</td>
<td>0.01</td>
<td>0.89</td>
<td>0.509</td>
<td>24</td>
<td>27.8</td>
</tr>
<tr>
<td>Surface stream</td>
<td>136</td>
<td>7.1</td>
<td>1.4</td>
<td>2.6</td>
<td>29</td>
<td>9</td>
<td>0.016</td>
<td>1.19</td>
<td>0.374</td>
<td>10</td>
<td>38.0</td>
</tr>
</tbody>
</table>

The values for EC is =dSm⁻¹, SAR= mSm⁻¹; other cations are = mg/L for the water values, while for the soil values is = Cmol/kg

The Chloride levels in both the tubewell and surface stream water as shown in Table 1 are; 0.89mg/L and 1.19mg/L respectively. According to the (WHO, 1998), any water with a chloride value above 10mg/L is considered harmful for both domestic and agricultural purposes. Therefore, the water at the study area falls far below those considered harmful by WHO standard. However, considering the mobility of Chlorides also and some domestic activities taking place in the surface stream water, there is every possibility that it’s level may increase with time, as it can be noted in the values for both tubewell and surface stream water as analyzed in this work as 0.89mg/L and 1.19mg/L respectively.

Boron concentrations

Boron concentrations of the water for both tubewell and surface stream are 0.509mg/L and 0.374mg/L respectively; these values when compared to the standard value given by Van Roojen et al., 2005 of 1.0mg/L can be considered safe for both domestic and agricultural purposes, but care should be taken in using these water especially the tubewell water, because boron is known to be toxic even at a lower concentration.

Concentrations of Basic cations

Basic cations concentrations for the tubewell water at the study area as shown in Table 1, Were; 1.1mg/L, for Ca, 1.7mg/L for Mg, 29mg/L for Na and 21mg/L for K, were considered slightly lower than the values of the surface stream water which has it values as 1.4mg/L for Ca, 2.6mg/L for Mg, 14mg/L for Na, and 9mg/L for K. This trend shows that in a near future if care is not taken, the use of this tubewell water can possibly results in the danger of sodicity. However, the concentrations of Ca and Mg do not pose any danger in a near future.

Turbidity

The turbidity level of the tubewell water and the surface stream water were given as 27.8 NTU and 38.0 NTU as shown in Table 1, does not pose any danger for using these water for both domestic and agricultural purposes when compared to the standard value given by (Ajdary, 2008) of 50NTU. However, the value of the surface stream water turbidity is higher than that of the tubewell water, this could be attributed to the fact that a lot of domestic activities were going on in the surface stream water such as washing of clothes, dishes and plates, swimming, fishing etc.

Soil characteristics along Jega Floodplains

Farmers along the Jega floodplains uses any water that is more readily available to them as at the time they wanted to irrigate their crops irrespective of the source. Therefore the soil characteristics that were presented in this work does not take care of the variations in the water sources, it only shows soil characteristics of the entire flood plains during active irrigation activities.

Particle size distribution

The overall mean results for pit A and pit B for the textural classification as indicated in Table 2, shows that pit A; sand 66%, silt 26% and clay 9% and for pit B; 58% is sand, 30% silt and 12% clay. When these results were ranked, the soil in this area was classified as sandy loam, and there was no any significant differences observed as far the depth as shown in Table 2.

Soil pH

The pH results as analyzed for both pit A and pit B, and at both depth that is 0-15cm and 15-30cm does not show any significant differences as far both location and depth. They are thus characterized as slightly acidic to slightly alkaline which are generally within the pH requirements of the majority of crops grown within this study area, so lime application becomes unnecessary. However, the use of acidic fertilizers should be minimized if cannot be avoided so as to prevent the build up of acidity and appropriate drainage should be provided for this soil to continue enjoying its current status.

Soil Electrical Conductivity (EC) and Sodium adsorption ratio (SAR)

The EC of this soil indicates that at both locations and
depths, there is no threat of higher EC or SAR as for now when compared with the standard given by (Miller et al., 2007), but care should be taken in selecting appropriate agricultural system for the area.

**Exchangeable Bases**

The concentration of Na at both locations and depths is significantly higher than all the other basic cations analyzed (Ca, Mg and K) as shown in Table 3. However, the concentrations of Ca, Mg and K were all within the average range found in a similar work carried out somewhere as reported by (Singh and Tsoho, 2000; Graham and Singh, 1997). Therefore, there is every possibility that this soil in a near future to could be acidic if care is not taken, so corrective measures such as minimizing the use of Na containing fertilizers, and plating crops that are high Na tolerant.

**Organic Carbon, Total Nitrogen and Available P**

The percentage Organic carbon in both locations and depth were rated as low as shown in Table 3, this is a typical characteristics of the majority soils within the savannah region, but when carefully observed, the results from the table in both locations and depths percentage organic carbon is higher at 0-15cm soil depth, this is obvious because it is where the deposition of the dead plants and animals are.

Total N concentrations in both locations and depths are regarded as low when compared with the standard given by (Esu, 1991). This result indicates the true characteristics of the savannah soils of low N content which could be attributed to higher volatile nature of N and the amount of solar radiation that were intercepted within the region.

The proportion of the available P within the study area at both locations and depths does not differ much with that obtained for organic carbon and total N, that is low concentration which as indicated before is a typical nature of the savannah soils. However, as P is not as mobile as N, the danger of P deficiency is no longer there.

**CEC and Boron content**

When compared with the standard values given by Jones and Wild 1975, both CEC and Boron content were regarded a low irrespective of locations and depths, therefore there is no fear of boron toxicity at the study area, the lower CEC at both locations and depths need to be looked into so as to enhanced the utilization of the exchangeable cations.

**CONCLUSIONS AND RECOMMENDATIONS**

Based on the results of this study, it can be concluded that both water and soils of the Jega floodplain are safe for both agricultural and domestic uses as at now, but considering the Na concentrations, there is every possibilities that sodicity might be a problem in a near future, and apart from this, the way and manner in which the surface stream water is put into use might likely import some toxic substances into this water and might

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**Table 2. Mean values of EC, pH, CEC, and Particle size distribution of the Jega Floodplain Soils**

<table>
<thead>
<tr>
<th>Location and Depth</th>
<th>EC (dSm⁻¹)</th>
<th>pH</th>
<th>Particle size (%)</th>
<th>CEC (Cmol/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H₂O</td>
<td>CaCl₂</td>
<td>sand</td>
<td>silt</td>
</tr>
<tr>
<td>Pit A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-15cm</td>
<td>0.39</td>
<td>7.8</td>
<td>7.3</td>
<td>61</td>
</tr>
<tr>
<td>15-30cm</td>
<td>0.38</td>
<td>7.3</td>
<td>6.5</td>
<td>70</td>
</tr>
<tr>
<td>Pit B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-15cm</td>
<td>0.31</td>
<td>7.1</td>
<td>6.7</td>
<td>52</td>
</tr>
<tr>
<td>15-30cm</td>
<td>0.33</td>
<td>6.9</td>
<td>6.6</td>
<td>64</td>
</tr>
</tbody>
</table>

The values for EC is =dSm⁻¹   SAR= mSm⁻¹
Other cations are = mg/L for the water values, while for the soil values is = Cmol/kg
SL= sandy loam; L= loam.

**Table 3. Mean values of EC, pH, OC, B, TN, Basic cations, Av. P, CEC, and SAR of the Jega floodplain Soils**

<table>
<thead>
<tr>
<th>Location and Depth</th>
<th>OC (%)</th>
<th>B (mg/L)</th>
<th>TN (%)</th>
<th>Ca (mg/L)</th>
<th>Mg (mg/L)</th>
<th>Na (mg/L)</th>
<th>K (mg/L)</th>
<th>Av. P (mg/L)</th>
<th>SAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-15cm</td>
<td>0.54</td>
<td>1.65</td>
<td>0.049</td>
<td>0.50</td>
<td>0.45</td>
<td>0.91</td>
<td>0.95</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>15-30cm</td>
<td>0.28</td>
<td>1.90</td>
<td>0.035</td>
<td>0.45</td>
<td>0.25</td>
<td>1.22</td>
<td>0.67</td>
<td>2.07</td>
<td>2.1</td>
</tr>
<tr>
<td>Pit B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-15cm</td>
<td>0.62</td>
<td>1.59</td>
<td>0.042</td>
<td>0.45</td>
<td>0.35</td>
<td>0.83</td>
<td>0.82</td>
<td>2.08</td>
<td>1.3</td>
</tr>
<tr>
<td>15-30cm</td>
<td>0.36</td>
<td>1.49</td>
<td>0.032</td>
<td>0.40</td>
<td>0.20</td>
<td>1.17</td>
<td>0.62</td>
<td>1.98</td>
<td>2.1</td>
</tr>
</tbody>
</table>
likely goes into the soil and be absorb by plants and can get into the human and animals that feeds on such crops. Therefore it is recommended that washing in the form of bathing, plates and pots, cars and other automobiles should be avoided, and the use of salt containing fertilizers should be minimized if it cannot be avoided, hence the use of animal dung as a source of organic manure is highly recommended.

REFERENCES


