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Assessment of water quality of river Navua, Fiji for irrigation purpose

■ INDRA RAJ SINGH AND SAURINDRA NR GOSWAMI

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MEMBERS OF RESEARCH FORUM:

Corresponding author :
INDRA RAJ SINGH, College of Agriculture, Fisheries and Forestry, Fiji National University, Koronivia Campus, Republic of Fiji, FIJI
Email: indrarajsingh@gmail.com

Co-authors :
SAURINDRA NR. GOSWAMI, College of Agriculture, Fisheries and Forestry, Fiji National University, Koronivia Campus, Republic of Fiji, FIJI

Summary

Quality of water has been a major concern due to ever increase in human development activities that over exploit and pollute the water resources. Water resources like rivers, lakes, canals etc. are generally used for agricultural production in most of the countries.The sustainable agricultural development depends on the efficient utilization of existing water resources; therefore, quality of irrigation water is an important criteria of consideration for sustainable agricultural production. Various scientific methods are generally used for determination of water quality. This paper is an attempt to analyze the water quality of river Navua in Fiji for irrigation purpose. Water samples for laboratory testing were collected from 6 different sampling sites. Water quality variables were measured and the samples were analyzed for pH, electrical conductivity (EC), total soluble salts (TSS), chloride content (CC), residual sodium carbonate (RSC) and sodium adsorption ratio (SAR). The evaluation of the irrigation water quality parameters as an indicator in the Navua River are summarized in this article.

Key words : Navua river, Irrigation water quality, Chloride, SAR, RSC

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Introduction

World is facing water crisis and water is the most essential necessity of life. Water resources have reached a point of crisis due to unplanned urbanization and industrialization (Singh *et al.,* 2002). Now-a-day's fresh water has become a scare commodity (Gupta and Shukla, 2006 and Singh and Mathur, 2005). Water resources like rivers, lakes, ponds, dams and canals are generally used for agricultural production in most of the countries. Quality of irrigation water is important criteria of consideration for sustainable agricultural production as water used for agricultural purposes determine the effect of water on the quality and yield of the crops, as well as the effect on soil characteristics (Ayers and Westcot, 1985). Water used for irrigation purpose always contains measurable amount of dissolved substances which are generally called salts. These include relatively small but important amounts of dissolved solids originating from dissolution or weathering of the rocks, soil and dissolving of lime, gypsum and other salt sources as water passesover or percolates through them. Since river water is devoted to agricultural uses, its quality should be assessed to safeguard public health and environment (Igbinosa and Okoh, 2009).

The water used from any source for irrigation purpose should be of good quality so that it can be used safely for production of agricultural crops without any

limitation. It is imperative to have reliable information on the characteristics of water quality for assessing its safety for irrigation and water resource management (Fan *et al.*, 2010).

Continuous application of irrigation water with high salts concentration may lead to build up high salt concentration in root zone that can adversely affect quality of soil and can decrease the production of agricultural crops. There are certain criteria's for determination of the quality of irrigation water and to check the concentration of dissolved substances in water upto a permissible limit. In this study, water samples from different locations are collected from Navua river from up stream to its down stream of the river Navua, Fiji.

Resource and Research Methods

The present study elucidates quality of irrigation water and the sample locations in the study are depicted in Fig.A. Water samples for laboratory testing were collected from 6 different sampling sites. Water quality variables were measured and the samples were analyzed.

Location :

The Navua river is located in the island of VitiLevu in Fiji and has its source on the south east slope of Mount Gordon and flows for 65 kilometers to the south coast. The river is the source of water for farmers of the study area and Navua town (Fig. A).

Water quality is determined for the purpose for which it is used. For irrigation waters, usually salinity, sodicity and other elements should be in a permissible limit. There are various parameters generally used to measure the quality of irrigation water.

There are certain criteria considered for assessment of the quality of irrigation water, whereby some are discussed below:

– pH of irrigation water;

– Salinity hazard or total concentration of soluble salts or electrical conductivity (EC);

– Sodium hazard or relative sodium concentration;

– Bicarbonate hazard – Residual sodium carbonate (RSC);

– Chloride concentration;

Standard methods as outlined in USDA, Hand book No. 60 were followed to determine these parameters.

Research Findings and Discussion

The samples collected from Navua river were analyzed and the results are summarized for suitability as per the criteria suggested by USDA.

Salinity hazard :

High salt containing water are generally toxic to most of the crops results in salinity hazard. Salinity can

Fig. A : Map of the study area with water sample locations

cause physiological drought to crops even when sufficient soil moisture is available. It is generally determined as total soluble salts (TSS) or EC (electric conductivity). EC (electric conductivity) is expressed as dS m^{-1} According to U.S. Salinity Laboratory, there are four classes of salinity *viz.*, C_1, C_2, C_3 and C_4. Water quality of Classes C_1 and C_2 are considered to be suitable (no problems) for irrigation purpose. The EC values (Table 1) of the sample number S_1 to S_3 were in the range of 0.021 to 0.074 dSm^{-1} whereas, EC values of the sample number S_4 to S_6 were in the range of 1.055 to 15.490 dSm^{-1}. The TSS values of the sample number S_1 to S_3 were in the range of 20 to 90mg L^{-1} whereas, TSS values (Table 1) of the sample no. S_4 to S_6 were in the range of 632.4 to 9320 mg lit^{-1}. Poor water quality associated with poor soil and water management may result in water logging and salinization which can deteriorate quality of soil and agricultural productivity (Bouksila *et al*., 2013). Consequently, high salt accumulation in the root zone leads to yield reductions (Ezlit *et al.*, 2010).

pH effect :

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 some toxic ions, whereas low pH may cause accelerated irrigation system corrosion. High pH above 8.5 are often caused by high carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) concentrations. The pH values (Table 1) of the all samples were found in the range of 7.06 to 7.77.

Sodium hazard :

High concentration of sodium are undesirable in water because sodium adsorb on the soil cation exchange sites, causing soil aggregates to break down (deflocculation), sealing the pores of the soil and making it impermeable to water flow. Water of low sodium (S_1) values presents little danger of exchangeable sodium; medium sodium water (S_2) whereas, high sodium (S_3) and very high sodium (S_4) are considered unsatisfactory for irrigation purpose. Sodium hazard is usually expressed in terms of sodium adsorption ratio (SAR) and SAR was calculated from the ratio of sodium to calcium and magnesium.

$$\text{Sodium adsorption ratio (SAR)} = \frac{\left[Na^+\right]}{\frac{\sqrt{Ca^{+2} + Mg^{+3}}}{2}}$$

The SAR values (Table 1) of the sample number S_1 to S_3 were in the range of 3.3 to 6.5 whereas SAR values of the sample number S_4 to S_6 were in the range of 32.1 to 93.0. Results indicate that sample number S_1 to S_3 fell under low sodium class whereas sample number S_4 to S_6 were in high sodium range. High sodium water may alter the availability of some elements concentrations which can be toxic to plants like boron, sodium and chloride (Kirda 1997 and Nishanthiny*et al*., 2010).

Carbonates and bicarbonate hazard :

Residual sodium carbonate (RSC) is used to evaluate the quality of irrigation water and expressed in meq/lit. The carbonate (CO_3^{2-}) and bicarbonate (HCO_3^{1-}) anion are important in irrigation water as regard to calcium and magnesium. This brings a change in the soluble sodium percentage (SSP) in irrigation water. According to U.S. Salinity Laboratory, a RSC value less than 1.25 meq/lit is safe for irrigation. A value between 1.25 and 2.5 meq/lit is of marginal quality and value more than 2.5 meq/lit is unsuitable for irrigation. In the present study RSC values (Table 1) of the all were in the range of 0.31 to 1.11 meq/lit. that is below 1.25 meq/lit. So water of Navua river can be considered safe for irrigation purpose as mentioned according to above considerations. Residual sodium carbonate (RSC) was calculated by given formula.

Table 1: Important quality parameters of Navua river water

Sampling site	EC (dSm^{-1})	Total soluble salts (TSS)	pH	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC) (meq/l)	Chloride content (CC) (meq/l)
S_1	0.021	20	7.06	3.3	0.31	2.50
S_2	0.034	40	7.75	3.0	0.80	4.50
S_3	0.074	90	7.11	6.5	0.46	7.50
S_4	1.055	632	7.26	32.1	0.44	8.48
S_5	2.10	1220	7.77	68.5	0.92	14.90
S_6	15.49	9320	7.52	93.0	1.11	98.10

$$\text{Residual sodium carbonate} = (RSC) = (CO_3^{-2} + HCO_3^{-}) - (Ca^{+2} + Mg^{+2})$$
(All ions expressed in meq/lit)

Chloride concentration :

Since the chloride has no effect on the physical properties of soil and is not adsorbed on the soil complex and so it has generally not been included in modern classification. However, it can be used as a factor in some regional water classification. Chloride concentration of less than 5 meq/lit can be safely use for agricultural purpose. The chloride content (Table 1) of the sample number S_1 to S_3 were in the range of 2.50 to 7.50meq/lit whereas the sample number S_4 to S_6 were in the range of 8.48 to 98.10meq/lit. Results indicates that sample number S_1 to S_3 were under permissible limit of chloride content whereas sample number $S_4$to S_6 possessesed very high chloride content and cannot be recommended for irrigation purpose.The high chloride content in water samples are mainly attributed to the dissolution of minerals (Alexakis, 2011).

Conclusion :

The study revealed that water samples (S_1, S_2 and S_3) were having permissible limits of soluble salts compared to water samples (S_4, S_5 and S_6). Therefore, the Navua river water can be safely used for irrigation purpose upto S_3 sampling site. As the river move downward because of high salt concentration quality of water is not suitable for irrigation purpose.

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