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Physico-chemical characteristics of water samples of Bantwal Taluk, south-western Karnataka, India

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Abstract: *Quality of water is an important criterion for evaluating the suitability of water for irrigation and drinking. In the present study, the analysis of water samples from different sources like open wells, bore wells, farm ponds and streams/rivers of twenty villages of Bantwal taluk of Dakshina Kannada district, South-western Karnataka has been carried out. The physico-chemical characteristics of this water showed that it is suitable for irrigation and agricultural purposes.*

Key words: *Water quality, RSBC, RSC, Salinity, SAR*
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Introduction

Water is an essential component of the environment and it sustains life on the earth. Human beings depend on water for their survival. Water is also a raw material for photosynthesis and therefore, is important for crop production. Obviously, an optimum agricultural production depends on water and soil quality (Sachidanandamurthy and Yajurvedi, 2006).

In south-western Karnataka, agricultural activities depend on different types of water sources. There are no reports on the physico-chemical properties of water resources of Bantwal taluk. Therefore, the present study was undertaken to test the water quality of different sources like open wells, bore wells, farm ponds and streams/ rivers of some selected areas of Bantwal taluk in Karnataka State.

Study area:

Bantwal is one of the five taluks of Dakshina Kannada district. It is situated between 12^0 40' N and 13^0 05' N latitude and 74^0 55' E and 75^0 15' E longitude. The total geographical area of Bantwal taluk is 735 km^2 (73, 500 hectares). There are 80 inhabited villages in the taluk. According to the 1991 census report, the population was 3,23,005 (male: 1,59,873; female: 1,63,132). The population density is 439/ km^2. Agriculture and related labour are the main occupation of the rural people.

The taluk has wet monsoon type climate. The annual average rainfall received is 3819 mm with around 124 rainy days. The river Netravati and its tributaries flow through the taluk in an east to west direction. Rice is the main agricultural crop (17,113 hectares). Green gram, black gram, horse gram and cowpea are also cultivated to some extent. Though sugar cane is grown here, it is only in small patches (72 hectares). However, cashew nuts, areca nuts, coconuts and to a small extent rubber are cultivated as plantation crops. Along with these, cocoa, banana, mango, jackfruit, sweet potato, tapioca, pineapple, beetle leaves and black pepper are also grown as mixed crops.

Materials and Methods

About 80 water samples were collected during November and December months of the year 2004. The water samples were collected from open wells, bore wells, farm ponds and streams/rivers from twenty villages of Bantwal taluk. The samples were collected in airtight plastic containers and transported to the laboratory where the samples were subjected to different analysis. pH of the samples was recorded using a pH meter (Toshniwal Instr. Pvt. Ltd., No. 54). Electrical conductivity was measured using Systronics Conductivity Meter-304. Acidity and alkalinity values were estimated by titration methods (APHA *et al.*, 1995), calcium and magnesium by EDTA method (APHA *et al.*, 1995), chloride by argentometric method (APHA *et al*., 1995, Manivasakam, 1996) and nitrate by brucine method (Manivasakam, 1996). However, sodium and potassium were determined by using a Systronics Flame Photometer-128.

To determine the suitability of water for agriculture, salinity hazard (C), sodium hazard (S) which is indicated by sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and residual sodium bicarbonate (RSBC) were calculated using the following formulae: (cations are expressed as milli equivalents/ litre).

$$RSC = [CO_3^{2-} + HCO_3^-] - [Ca^{2+} + Mg^{2+}]$$

$$RSBC = (HCO_3^- - Ca^{2+})$$

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

The salinity hazard (C) was calculated based on electrical conductivity value at 25°C expressed as mmohs/cm.

Results and Discussion

The analysis of pH, salinity, sodium, potassium, magnesium, calcium, alkalinity, carbonate, bicarbonate, nitrate and chloride contents revealed the suitability of water for irrigation purposes in different villages of Bantwal taluk. The results are given in Table 1 and have been discussed in the following paragraphs:

pH:

Normal range of pH in the irrigation water is 6.5 to 8.4 (Ayers and Westcot, 1985; KSPCBOA, 2000). All the water samples tested except one bore well sample from Karpe (pH 8.46) and one open well sample from Irvathur (pH 6.06) had a pH within this range. The mean pH values of different sources have been illustrated in Fig. 1.

Salinity:

An electrical conductivity (EC) of up to 700 µmohs/cm has no effects; whereas, an EC of 700 µmohs/cm to 3000 µmohs/cm has slight to moderate effect on plants EC values of more than 3000 µmohs/cm will severely affect the crop water availability (Ayers and Westcot, 1985). Water with a high salinity is toxic to most plants and poses a salinity hazard. According to the EC value, the waters have been classified as;

Class	EC value (µmohs/cm)	Suitability
1	≤250	excellent
2	250-750	good
3	750-2000	permissible (leaching is required if used)
4	2000-3000	doubtful (good drainage needed if used)
5	>3000	unsuitable (good drainage needed if used)

The mean EC of water samples was wells, highest in bore wells followed by open well, pond and least in stream (Fig. 1)

High sodium levels can contribute to salinity problems and interfere with magnesium and calcium availability and it also indicates sodium hazard. The Pollution Control Board has prescribed 26 as the maximum tolerance limit value of SAR (KSPCBOA, 2000). The mean sodium, potassium, magnesium and calcium content of samples from open wells, bore wells, ponds and streams/rivers are illustrated in Fig. 2.

Table - 1: Mean value of water quality parameters of different sources in Bantwal taluk

Parameters	Sources			
	Open well	Bore wells	Farm ponds	Streams/ Rivers
pH	7.39±0.40 (peak: 8.21)	8.04±0.30 (peak: 8.46)	7.56±0.33 (peak: 8.20)	7.57±0.25 (peak: 8.15)
Electrical conductivity (µmohs /cm)	88.50±63.93 (peak: 250)	185±83.76 (peak: 380)	69.5±59.25 (peak: 220)	43.00±18.09 (peak: 90.00)
Carbonate (mg/l)	0.54±2.41 (peak: 10.8)	11.83±10.41 (peak: 32.4)	3.78±9.45 (peak: 32.40)	1.62±5.28 (peak: 21.60)
Bicarbonate (mg/l)	66.43±27.01 (peak:109.80)	202.03±107.13 (peak: 428.22)	66.43±28.83 (peak: 120.78)	67.38±22.27 (peak: 120.78)
Calcium (mg/l)	5.26±2.92 (peak: 11.52)	16.20±1011 (peak: 43.20)	5.62±3.91 (peak: 17.28)	4.32±1.32 (peak: 7.20)
Magnesium (mg/l)	2.16±0.95 (peak: 4.32)	6.74±2.94 (peak: 11.23)	2.98±2.05 (8.64)	2.20±0.76 (peak: 3.46)
Sodium (mg/l)	53.45±27.53 (peak: 103.7)	54.92±18.16 (peak: 104.20)	40.43±22.35 (peak: 99.20)	27.75±9.32 (peak: 47.60)
Potassium (mg/l)	14.16±19.28 (peak: 7202)	14.56±8.14 (peak: 29.3)	6.27±7.32 (peak: 25.80)	3.93±2.849 (peak: 13.70)
Acidity (mg/l of $CaCO_3$)	2.6±1.23 (peak: 7.0)	0.45±1.15 (peak: 5.0)	2.90±1.37 (peak: 8.0)	2.65±0.74 (peak:4.0)
Chloride (mg/l)	12.76±9.20 (peak: 31.76)	7.47±2.55 (peak: 13.16)	9.18±5.77 (peak: 23.82)	7.15±3.69 (peak: 14.36)
Nitrate nitrogen (mg/l)	2.76±0.48 (peak: 3.40)	2.41±0.63 (peak: 3.20)	2.53±0.60 (peak: 3.25)	2.33±0.77 (peak:3.35)

(note: values in parentheses indicate highest value of a parameter observed among the samples tested)
20 samples each from different sources have been tested

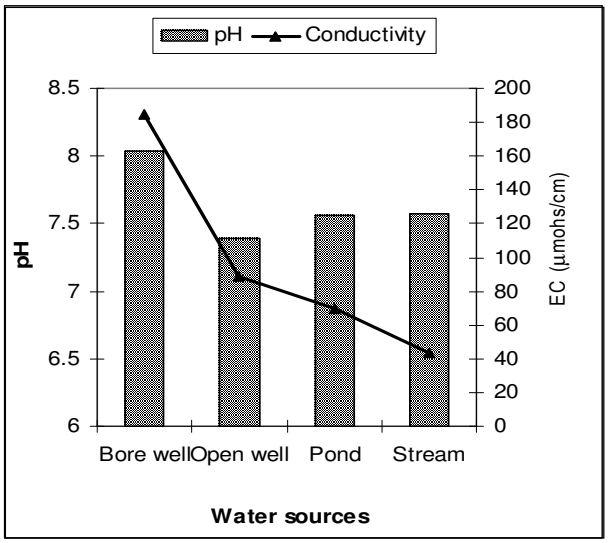

Fig. 1: Mean values of pH and conductivity in different water sources

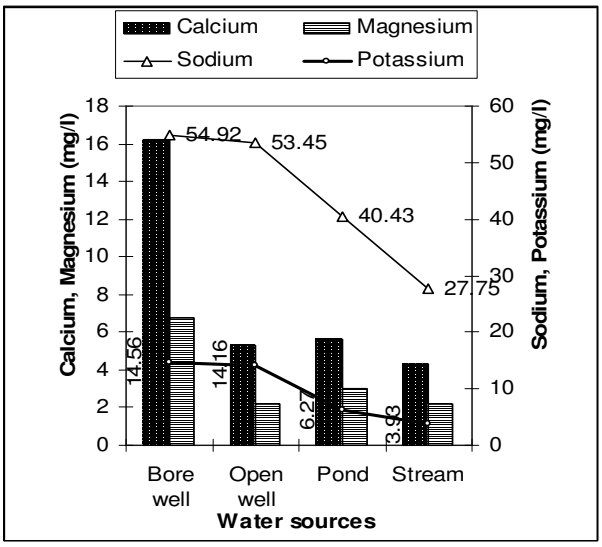

Fig. 2: Mean values of Ca, Mg, Na and K in different water sources

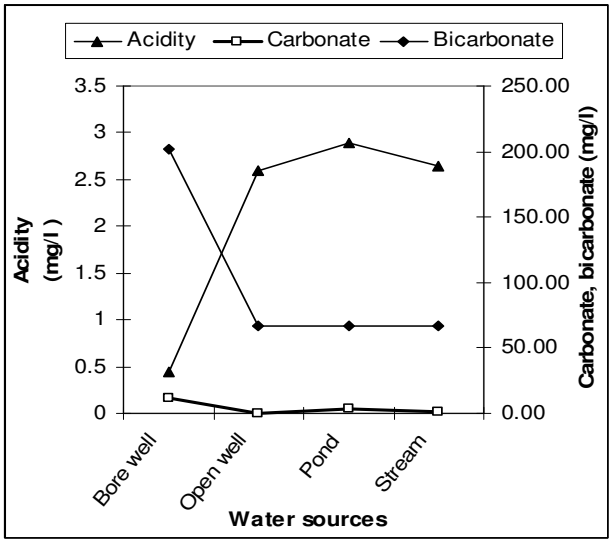

Fig. 3: Mean values of acidity, CO_3 and HCO_3 in different water sources

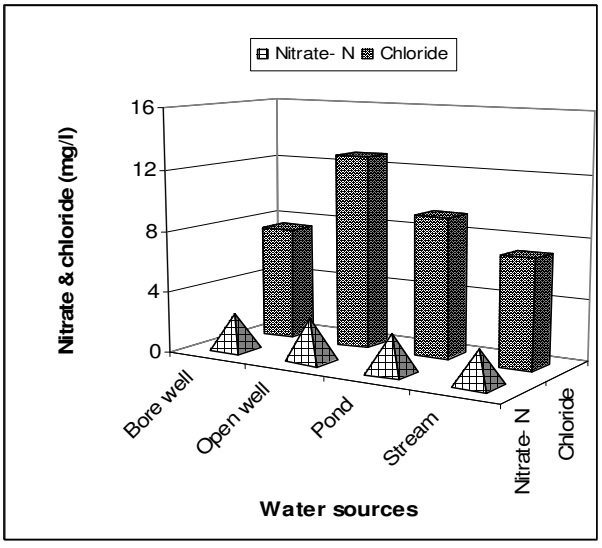

Fig. 4: Mean values of NO_3^- and Cl^- in different water sources

Alkalinity:

Alkalinity of the water source is more significant than its pH because it takes into account the principal constituents that influence the water's ability to regulate the pH of the medium. Alkalinity increases as the amount of dissolved carbonates and bicarbonates increase (Flood, 1996; Radha Krishnan *et al.*, 2007). The mean carbonate and bi-carbonate content of water samples from open wells, bore wells, ponds and streams/rivers have been graphically represented in Fig. 3.

Nitrate (NO_3^-):

The nitrate-nitrogen content of all the samples from open wells, bore wells, ponds and streams/ rivers falls within the range of 0.35 mg/l –3.4 mg/l (Fig. 4).

Chloride (Cl^-):

Chloride is often associated with sodium since sodium chloride is a common constituent of some water sources, especially well water. Levels above 140 ppm are considered to be toxic for plants (Flood, 1996). However, a value of 600 mg/l has been set as the tolerance limit for irrigation water (KSCBOA, 2000).

The mean chloride content of open wells, bore wells, ponds and streams/river are depicted in Fig. 4, indicating that the values were well within the tolerance limit.

Sodium hazard (S) or sodium adsorption ratio (SAR):

Sodium hazard is expressed as sodium adsorption ratio (SAR). The SAR is calculated from the ratio of sodium to calcium and magnesium. The latter two ions play a detrimental role as their

presence counters the effect of sodium. The SAR values are grouped into four classes:

Class	SAR value	Hazard
1	1-10	low
2	10-18	medium
3	18-26	high
4	> 26	very high

Residual sodium carbonate (RSC):

RSC gives an account of calcium and magnesium in the water sample as compared to carbonate and bicarbonate ions (Eaton, 1950). RSC value less than 1.25 indicates low hazard, whereas a value of 1.25- 2.5 indicates medium hazard and more than 2.5 indicates high hazard to crop growth. According to RSC classification, out of the eighty water samples tested, 25 percent of bore well samples pose a high RSC, 40 percent bore well samples, 10 percent pond samples and 5 percent each of open well samples and stream samples pose medium hazard and rest of the samples pose low hazard.

Residual sodium bi-carbonate (RSBC):

RSBC is the excess concentration of bicarbonate to calcium ion (Hussain and Hussain, 2004). The RSBC value classifies irrigation water into three groups: safe, marginal and unsafe (Wilcox, 1955). As per this classification all the eighty samples tested have a value below 5 and are safe for irrigation.

The United States Salinity Laboratory (USSL) classification (Richard, 1954) considers SAR and electrical conductivity values together to evaluate the suitability of water for irrigation. According to this classification, all the water samples except one open well sample from Thumbe (SAR: 10.62: moderate water), fall under good water category with low sodium hazard (SAR: 0-10).

Out of the 80 samples tested in Bantwal taluk, 85 percent of bore well samples, 95 percent of open well samples and all the pond and stream samples belong to C1-S1 class under USSL system of classification. 15 percent of bore well samples belong to C2-S1 class. 5 percent of open well samples belong to C1- S2 class indicating that most of the water used for irrigation does not need any special treatment before irrigation.

The water with SAR: 6-12 is considered as medium –sodium water and will present an appreciable sodium hazard in certain fine-textured soils. Such water may be used safely on coarse textured soils or organic soils that have good permeability (Richard, 1954).

Several authors have reported the suitability of water for irrigation from different parts of the world (Hussain and Hussain, 2004, Islam *et al.*, 2003, Meena Kumari and Hosamani, 2004; Rajesh and Murthy, 2004; Singh, 1998; Usha Madhuri *et al.,* 2004) and different sources (Malini *et al.,* 2003, Rao and Devadas, 2005; Satya Narayan and Guru Prasad, 2006; Vishwanath and Anantha Murthy, 2005). The present study reports the suitability of water sources of Bantwal taluk for irrigation.

In the present work, physico-chemical parameters likes pH, sodium, calcium, magnesium, chloride and nitrates of the water samples analysed from bore wells, open wells, ponds and streams/ rivers were well within the permissible limits for drinking water recommended by BIS (1991) and WHO (1984). These water sources were also found suitable for irrigation without further treatment. However, the authors are investigating the effect of the physico-chemical parameters of the water from the study area on the pathogens, which will be published separately.

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