HYDROCHEMICAL STUDIES FOR SUSTAINABLE WATER RESOURCES OF SEMI- ARID CLIMATIC REGION DODBALLAPUR TALUK,BANGALORE URBAN DISTRICT, KARNATAKA STATE (SOUTH INDIA)

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Abstract

The 21st century has been declared the century of water, and we have every responsibility to find proper solutions to water crisis witnessed all over the world. A large part of the world's population especially people living in the developing countries is experiencing water stress resulting in water shortages and pollution. In many areas, water supplies for industrial, domestic and agricultural needs are dependent on groundwater. More than 85% of the rural water supply is being provided through groundwater. It is observed that areas experiencing declining water levels are also facing the problems of increase in the concentration of solutes, which may result in the deterioration of groundwater quality. In view of this, two sub-watersheds located in semi-arid region (water stressed region) in Southern India Karnataka State, Bangalore rural district, Dodballapur Taluk are taken up for intensive studies, broadly covering hydrologic, soils, water(surface and sub-surface) quantity and quality, water requirement of crops and the like.

Keywords- *chemical classification, chemical characteristics, groundwater, water quality, water hardness*

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1. INTRODUCTION

In the meantime the disruptions to the water cycle over Karnataka in the coming years as a result of climate change makes citizen sector intervention even more of a necessity. The major part of the state experiences tropical climate with bulk of the annual rainfall is received during the south-west monsoon (June to September). North-east monsoon (October-December) also contributes to a certain extent. Pre-monsoon thunderstorms are significant. Humid to semiarid climatic conditions prevail in the state. In general, rainfall varies from around 400 mm in certain parts of the vast eastern plains of the state to more than 4000mm in the coastal belt.

The two sub-watersheds under study, viz., Melekote and Rajaghatta cover 70.68 sqkm in extent. There are 22 small lakes/ tanks inside the boundary of the watersheds and as such there are no perennial streams. The annual rainfall over the watersheds is 976mm falling within 58 days. The rest of the water year is dry. They are nearer to the foot of Nandi Hills where River Arkavati takes its origin. There are fifty two villages, and the soils come under A, B, C and D hydrologic soil groups. Water quality is fairly good and the village community uses the available water for domestic and irrigational purpose. The main crops grown are ragi, jowar, pulses and vegetables.

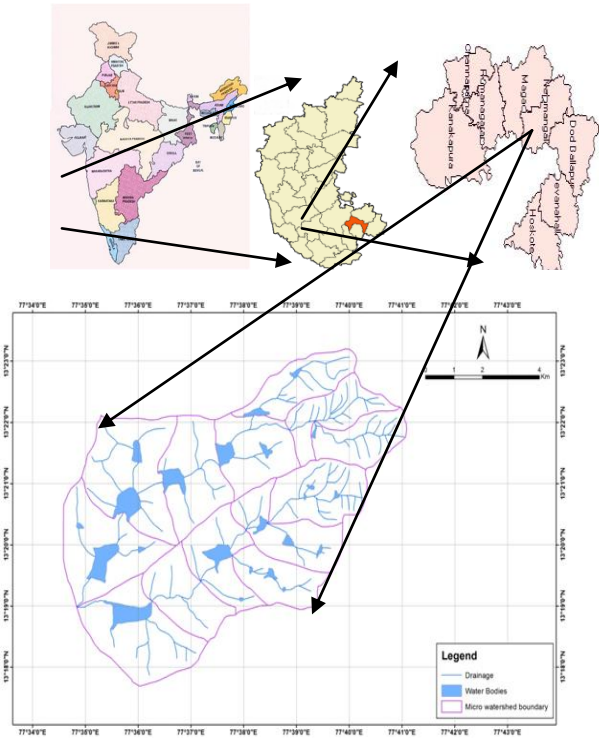
At the moment, 16 water samples and 16 soil samples have been collected during pre-monsoon and post-monsoon , and all the samples are subjected to physical and chemical tests adhering to BIS. An attempt is also made to assess the run off using Curve-Number method and soil erosion through USL equation. Depending upon the quality of water and soil, crops that can be grown are recommended. In addition, water management measures are also listed which help the farmers in achieving economy in farming and steps to sustain groundwater and to ensure access to a minimum quantity of potable water for essential health and hygiene to the entire rural community.

2. STUDY AREA

The study area falls within the boundary of Dodballapur taluk, which is a part of Bangalore rural district, having semi-arid climate, receiving 976mm of rainfall annually. The district is quite near to Bangalore International Airport (BIA) and

adjoining Andhra Pradesh State border. But the area suffers from shortage of water and illegal sand mining is a menace. If sand mining is arrested the population can have solace for groundwater availability.

The authorities are planning to bring water from Western Ghats region, to mitigate the drinking water problem. No doubt, the government is taking steps to develop the taluk in all sectors. Thus, it becomes a necessity to take up intensive step to protect our natural resource, i.e., water. We have to assess the quantum of water available for utilization, which means water resources estimation. As a pilot study two sub-watersheds are considered for investigation covering mainly hydrological aspects.



The two watersheds fall within the geographical boundary of Dodballapur taluk (792 sq.km) , one of the four taluks in Bangalore rural district . They come under the confluence of Kumudauvathy river catchment, a tributary to river Arkavati joining the Cauvery river downstream. Melekote and Rajaghatta combined watersheds cover an area of 98.5km^2.They fall between: 13077'41''and 13^0 23' 15'' south latitude: 77^0 34' 24'' and 77^0 40' 20'' east longitude.

The taluk is in semi-arid region, receives about 796 mm of rainfall annually with 58 rainy days. The area suffers from erratic rainfall, shortage of water, and uncontrolled sand mining. The catchments receive rainfall mainly from south-west monsoon, and the humidity never exceeds 50%. Broadly speaking the entire taluk suffers from water scarcity, natural resource degradation,

3. PHYSIOGRAPHY, GEOLOGY AND SOILS

The taluk namely Dodballapur forms a gently sloping rolling topography with the slope from north to south amounting to 5%. There are 52 villages inside the catchment boundary and the population is 45,928. The entire population depends upon groundwater for domestic needs. An industrial conurbation has been set up at Dobaspet taking away the fertile land from the farmers. There are good number of silk garment factories in the taluk.

The area consists one of the oldest rock formations of Archaen age. Peninsular gneisses cover large portion of the Bangalore district. They are highly migmatitic in nature. Their composition is of granodioritic material. Gneisses are generally grey in colour. They are jointed with sheet joints almost parallel to the ground surface. The granites are medium to coarse grained, and equigranular in texture. Dykes are oriented east west as well as north south.

The study area has red loamy soils and they are fairly well drained. Slopes range from 1 to 3 percent, slightly moderately eroded. Alluvial deposits are noticed over a small area. Infiltration rates range from 8 to 12mm/hour.

Major portion of the district is drained by river Arkavati (4166 sq km), the Kanva (824 sq km) and the Shimsha (468 sq km) which are tributaries to river Cauvery. The northern portion is drained by North Pinakini (535sq km) and the eastern part is drained by South Pinakini (1966sq km). A small portion of the north eastern portion is drained by Palar (66 sq km). Geomorphologically we find residual hills, granites and charnockites with varying elevations, aerial extent and dissection. Pediplains also found gently undulating with fairly thick weathered mantle over granites and gneisses.

4. METHODOLOGY OF INVESTIGATION AND RESULTS

(i) Two adjoining sub-catchments (Melekote and Rajaghatta) are falling within- Dodballapur, Devnahalli taluks of Bangalore rural district and a little area in Chikballapur taluk of Chikballapur district. In and around the two sub-catchments we have considered 4 daily read raingauges with 5 years of gauging records and the same have been synthesized for further analysis through isohyetal maps. The average annual rainfall depth over the two sub-catchments works out 976 mm. There is no provision for stream gauging within the study boundary.

(ii) Drainage basin analysis based on morphometric parameters is very important for watershed planning since it gives an idea about the basin characteristics in terms of slope, topography, soil condition, runoff characteristics, surface water potential, etc. The development of land forms and drainage network depends on rock type and associated

geologic structures. The two sub-catchments geomorphologically, vary with elevations, areal extent and dissection from north to south. These two sub-catchments have developed 5th order streams indicating similar level of maturity attained. The relief ratio is less than 0.07 resulting in low relief. Linear characteristics are listed below-

Number of streams : 105;
Total length of streams : 109 45 km;
Bifurcation ratio : 3.25;
Drainage density : 1.55km/sq km;
Stream frequency : 1.49;
Length of overland flow : 0.77;
Relief ratio : 0.00384;
Ruggedness number : 0.217;
Form factor : 0.44;
Compactness coefficient : 1.22;
Circularity ratio : 0.67

Drainage density of 1.55 indicates average permeability in the sub-catchments. In areas of low relief, drainage density may be more indicative of permeability of surface material and hence could be used as a criterion for the selection of suitable sites for deep wells. Also, drainage density influences runoff pattern and thereby infiltration capacity of the rock material. The circularity ratio of 0.67 exhibits catchments' maturity and old age topography.

(iii) Infiltration is the flow or movement of water through the soil surfaces in to the soil. Infiltration of surface water into the soil becomes soil moisture, subsurface flow or unsaturated flow through the soil and groundwater flow or saturated flow through soil or rock strata. Infiltration is a very complex process. Infiltration rate is influenced by condition of the soil surface and vegetation, properties of the soil such as porosity, hydraulic conductivity and the in-situ moisture condition. Horton (1939) observed that infiltration begins at some rate f_o and exponentially decreases until it reaches a constant rate f_c. $f_t = f_c + (f_o - f_c)^{e-kt}$, where k is a decay constant with dimension T^{-1}.

The k is influenced by catchment and rainfall characteristics. We have chosen six locations for field investigation by using double-ring infiltrometer. The value of k varies from 5.81 to 15.7 depending upon the soil compactness.

(iv) The term 'soil' is a collective term for all soils. Soil is a living dynamic and complex system derived out of the action of climate, vegetation and topography on the parent material over a period of time. Common interest exists between soil chemistry and water chemistry. Karnataka state presents diversified crops and patterns dictated mainly by the climate, soils, topography and irrigational facilities.

Soils are formed due to chemical weathering and mechanical disintegration of rocks. Soil quality standards are used as a means to maintain long-term soil productivity. Soil quality is usually expressed in terms of its degradation. Soils of the study area can be expressed based on colour, texture and composition.

Table 1: Maximum and minimum concentrations of major ions in groundwater samples

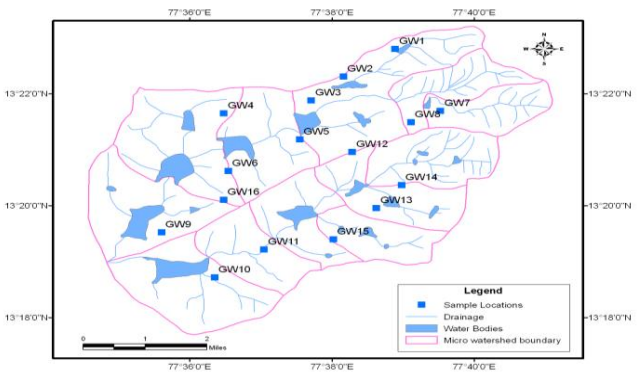
Ions	Monsoon Samples (meql^{-})		Post-monsoon Samples meql^{-}	
	min	max	min	max
Na^{+}	0.52	2.52	0.43	3.13
K^{+}	0.1	0.33	0.0	0.17
Ca^{+2}	0.43	6.68	0.55	4.11
Mg^{+2}	0.11	2.79	0.31	3.99
CO_3^{-2}	0.55	3.78	0.55	5.03
HCO_3^{-1}	0.005	0.05	0.001	0.016
Cl^{-1}	0.14	4.03	0.70	3.94
SO_4^{-2}	0.15	1.31	0.3	1.22
Total hardness	0.45	6.09	0.7	5.40

According to the US Department of Agriculture, water having more than 2.5 epm of RSC is not suitable for irrigation purposes. Groundwater of the study area is classified on the basis of RSC and the results are presented in Table 2for both pre- monsoon and monsoon seasons.

Table 2: Groundwater quality based on RSC (Residual Sodium carbonate)

RSC (epm)	Remark on Quality	monsoon samples	post-monsoon samples
<1.25	Good	0.27-0.35	0.169-0.234
(16 samples)		(16 samples)	
1.25-2.5	Doubtful	_	_
>2.5	Unsuitable	_	_

Based on RSC values, all 16 samples have values less than 1.25 and are safe for irrigation during monsoon and post-monsoon periods.



Groundwater sampling locations of Melekote Rajaghatta sub-watersheds

GW1 =Chickarayappanahall GW2 = Doddarayappanahalli
GW3 = Melekote GW4 = Gantiganahalli
GW5 = Chougondanahalli GW6 = Beedikere
GW7 = Seegehalli GW8 =Hegadehalli
GW9 = Rajaghatta GW10=Konaghatta
GW11= Linganahalli GW12 =Kodigehalli
GW13= Sonmaranahalli GW14= Nandigunda
GW15 = Rabbanahalli GW16= Gulya

According to Sawyer and McCarthy's classification for hardness, sample 7 and 3 fall under moderately hard class and samples 5 and 10 fall under hard and 1 and 2 fall very hard class for monsoon and post-monsoon water samples. The hardness classification is given in Table 3. The suitability of groundwater for irrigation depends on its mineral constituents.

Table 3: Classification of water based on hardness Sawyer and McCarthy

Hardness as $CaCO_3$ (ppm)	Water class	monsoon samples	Post-monsoon samples
0-75	soft	40-75 (3 sample)	40-75 (1 sample)
75-150	Moderate Hard	95-150 (7 samples)	124-150 (3 samples)
150-300	Hard	152-300 (5 samples)	170-300 (10 samples)
>300	Very hard	305-480 (1 sample)	300-330 (2 samples)

The most important characteristics of irrigation water in determining its quality are [i] Total concentration of soluble salts; [ii] Relative proportion of sodium to other principal cations; [iii] Concentration of boron or other elements that may be toxic, and [iv] Under some condition, bicarbonate concentration as related to the concentration of calcium plus magnesium. These are termed as salinity hazard , namely sodium hazard, boron hazard and bicarbonate hazard. In the past, the sodium hazard has been expressed as percent sodium of total cations. A better measure of sodium hazard for irrigation is the SAR value is used if it is less than 10,

Table 4: Sodium percent water class

Sodium%	Water class	Monsoon samples	Post-Monsoon samples
<20	Excellent	19.85-19.94 (2 samples)	9.00-19.00 (6 samples)
20-40	Good	24.78-38.94 (9 samples)	24.00-37.00 (6 samples)
40-60	Permissible	40.6-48.6 (5 samples)	40.00-52.00 (3 samples)
60-80	Doubtful	_	72.00 (1 samples)
>80	Unsuitable	_	_

It is classified as excellent for irrigation. When the SAR and specific conductance of water are known, the classification of water for irrigation can be determined graphically by plotting these values on the US salinity [USSL] diagram. The groundwater of the study area is in general Ca-Mg-HCO_3 type during both monsoon and post- monsoon seasons of the year 2011. About 85% of the samples are grouped within C2S1 class in both monsoon and post-monsoon period.

5. CONCLUSIONS

The two sub-watersheds namely Melekote and Rajaghatta have eight micro-watersheds each. They all finally drain into a single outlet point. Since there are no perennial rivers, the farmers have to depend upon the existing tanks (or lakes), wells, borewells for water to be used for crops and domestic use. In many cases the quality of water is not fit for use. High rate of fertilizer use has resulted in land degradation. Since atmospheric CO_2 is the sole source of carbon for plants, variations in its concentration have obvious implications for plant growth. To the crops, carbon is supplied from the atmosphere and other essential nutrients (N, P, Zn and Fe) are supplied from the soil.

The results of the chemical analyses of water and soil samples reveal that there are no abnormalities.

The two sub-watersheds are of unexplored water stressed region with regard to soil and water resources. Further, much exploratory work .is yet to be carried out in respect of soil erosion, soil productivity, and bacterialogical aspects of water besides hydrological characteristics of the catchments.

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BIOGRAPHIES

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R.Druvashree has BSc (Agri) and MSc Bio-chemistry from UAS GKVK Bangalore. She worked as research assistant in Don funded project by Govt. of Karnataka for the period of 6 months. She published 3 peer revived Journal papers and 10 research papers published in the conferences held International and national conferences.