

A comparative study of ground water quality and water quality index of certain selected areas situated around Tumkur city, Karnataka

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ABSTRACT

Ground water is believed to be comparatively clean and free from pollution than surface water. Prolonged discharge of domestic sewage and solid waste causes the ground water to become polluted and create health hazards, but the National Water Policy (2002) states, "adequate clean water should be provided to the entire population both in urban and rural areas". Therefore the ground water samples from 15 locations of 5 selected areas namely, Kadaba, Kallambella, Honnudiike, Hebbur and Kunigal of situated around Tumkur city have been collected from August to December, 2007 and analyzed for physico-chemical parameters. The values obtained were compared with standards prescribed by ISI and WHO. The data have revealed that certain water samples from Kallambella, Kadaba and Honnudiike area have high nitrate level and are of immediate health concern. The water samples of Kallambella area were found to be too hard. The Canadian Council of Ministers of The Environment (CCEM) water quality index (WQI) values were calculated from a few samples of selected areas and compared with the approved values. The results so obtained would account for the fact that the water samples from Hebbur (S₁) and Kunigal (S₂) area are of excellent quality; samples (S₂) of Kadada area are of good quality, samples (S₁) of Honnudiike area are of fair quality whereas samples (S₂) of Kallambella area are of marginal quality.

Key words: Physico-chemical parameters, Ground water quality, Water quality indexes, Selected areas, Tumkur, Karnataka.

INTRODUCTION

Ground water is considered to be safe when compared to surface water and accounts for maximum share of drinking water supply. Ground water is also an important source for agriculture and industry. It is less prone to contamination but normally having high mineral content, still an important water resource compared to surface water. However, excessive uses of chemicals and fertilizers have increases the risk of ground water contamination¹ that would affect ecosystem². There are reports showing ground water is not only contaminated but also deteriorated³.

As ground water is an important and integral part of hydrological cycle, its availability

depends on the rainfall and recharge conditions. Improper management and environmental degradation are making such valuable water resources depleting and creating a fresh water crisis, that may account for an estimate that puts 30% of mortality and 50% of morbidity to water borne infections diseases⁴. Therefore, there is a need for monitoring and understanding water quality. Its quality index values reflect the over all and ongoing condition of the water in a chosen area. As a consequence, innumerable methods are developed to evaluate quality index including the British Columbia (BC) Ministry of Environment, Lands and Parks⁵, which is based on a combination of three factors.

1. The number of variable whose objectives are not met, F₁ (Scope).

2. The frequency with which the objectives are not met, F_2 (frequency) and
3. The amount by which the objectives are not met, F_3 (Amplitude).

These are combined to produce a single value (between 0 and 100) that describes water quality. The CCME WQI⁶ relies on BC and Alberta indices with little modifications. In the CCME WQI, a value of 100 is the best possible index score and a value of 0 is the worst possible. The water body, time period, variables index score and a objectives need to be defined to calculate the index. The calculation requires that at least four variables, sampled a minimum of four times, be used. However, a maximum number of variables of samples are not specified. The selection of appropriate water quality variables for a particular region is necessary for the index of yield meaningful results. All these¹⁻⁵ have prompted the word presented here.

MATERIAL AND METHODS

Study area

The areas, namely Kadaba, Kallambella, Honnudike, Hebbur and Kunigal that are situated around Tumkur city have been selected to study their water qualities. Three localities from each area totaling to 15 were chosen for the collection of water samples from bore wells and hand pumps with care to avoid accidental contamination. Water quality parameters such as pH, EC, TH, nitrate, fluoride,

calcium, magnesium, iron and lead were analyzed through standard methods given in APHA⁷ and chemical and biological methods for water pollution studies⁸. The pH was determined using a digital pH meter. DO was determined by Winkler's iodometric method. Nitrate was determined by Brucine method. Fluoride was analyzed spectrophotometrically by SPANDS method. While chloride and alkalinity were analyzed by titrimetric method. Total hardness and calcium hardness were determined by EDTA complexometric method. The concentration of sodium and potassium were determined by flame photometric method. However heavy metals were analyzed at the Mines and Geology department, Bangalore following AAS method. The data obtained are given in Table 1. The CCME water quality index values were also calculated for a few selected samples as representative of the selected areas through the equation.

$$\text{CCME WQI} = 100 - \frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}$$

where F_1 , F_2 and F_3 are as described under introduction.

The divisor 1.732 normalizes the resultant values to a range between 0 and 100, where 0 represents the 'worst' water quality and 100 represents the 'best' water quality. In calculating the index values five months data for six variables have been used.

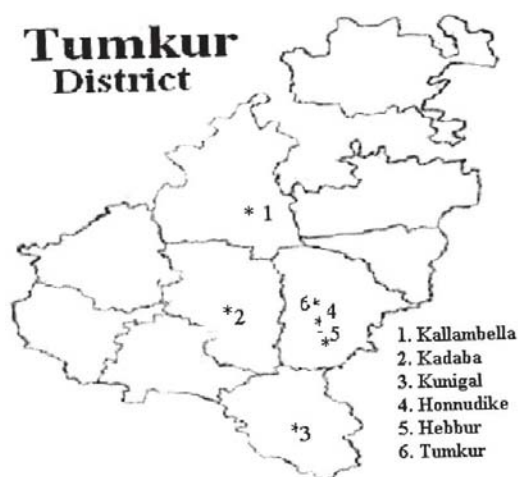


Fig. 1:

RESULTS AND DISCUSSION**pH**

The pH values of water samples of the study areas were ranged from 7.4 to 8.2 that are in the desirable range set by WHO⁹. However, the pH

values of the samples of Kadaba, Kallambella and Kunigal are accounting for a slight alkalinity and non-corrosive nature. The pH values as such have no adverse effect on health, but higher pH values reduce the germicidal potentiality of chlorine and induce the formation of toxic trihalomethanes.

**Water quality index values
Kadaba ground water - 2007 (sample -2)**

Date	Domg/L	pH	TH	Nitrate	Fluoride	Iron
Aug 07	6.3	7.9	243	39.5	0.25	0.38
Sep 07	6.2	8.1	210	40.3	0.36	0.52
Oct 07	7.1	8.2	218	49.0	0.43	0.47
Nov 07	7.0	7.7	199	42.7	0.52	0.62
Dec 07	6.7	7.6	191	41.6	0.41	0.29
Objective	5.0	6.5-9.0	500	45.0	1.5	1.0

CMCE WQI = 91.2

Kallambella ground water - 2007 (Sample 2)

Date	Domg/L	pH	TH	Nitrate	Fluoride	Iron
Aug 07	6.1	8.0	736	38	1.68	0.38
Sep 07	6.1	8.2	668	21	1.34	0.48
Oct 07	7.3	7.9	484	56	1.04	1.17
Nov 07	6.9	8.1	478	48	0.98	0.76
Dec 07	6.7	7.8	530	39	1.14	0.69
Objective	5.0	6.5-9.0	500	45.0	1.5	1.0

CMCE WQI = 59

Honnudike ground water - 2007 (Sample 1)

Date	Domg/L	pH	TH	Nitrate	Fluoride	Iron
Aug 07	6.2	7.6	669	34.4	0.68	0.23
Sep 07	6.3	7.7	594	29.1	0.81	0.19
Oct 07	7.4	7.3	498	42.7	0.45	0.81
Nov 07	6.8	7.5	625	54.3	0.57	1.23
Dec 07	6.5	7.5	678	39.8	0.62	0.76
Objective	5.0	6.5-9.0	500	45.0	1.5	1.0

CMCE WQI = 68.6

Kunigal ground water - 2007 (Sample 2)

Date	Domg/L	pH	TH	Nitrate	Fluoride	Iron
Aug 07	6.4	7.8	334	19.2	0.19	0.29
Sep 07	6.7	8.2	330	15.6	0.24	0.31
Oct 07	7.7	8.0	341	21.8	0.32	0.41
Nov 07	6.8	7.9	296	24.1	0.24	0.41
Dec 07	7.1	8.1	301	18.6	0.21	0.27
Objective	5.0	6.5-9.0	500	45.0	1.5	1.0

CMCE WQI >95

Hebbur ground water - 2007 (Sample 1)

Date	Domg/L	pH	TH	Nitrate	Fluoride	Iron
Aug 07	6.1	7.3	294	12.3	0.29	0.41
Sep 07	6.2	7.5	284	11.1	0.27	0.36
Oct 07	7.6	7.8	276	14.7	0.31	0.21
Nov 07	6.9	7.4	285	16.8	0.48	0.42
Dec 07	6.7	7.7	297	15.1	0.37	0.37
Objective	5.0	6.5-9.0	500	45.0	1.5	1.0

CMCE WQI >95

Dissolved oxygen

DO level will depend on the physico-chemical and biological activities of the water body. Good potable water is expected to have the DO in the range of 7.0 to 0.9 mg/L at 20-30°C². The samples of the present study having DO in range, 6.5-8.2 mg/L and accounting for the observed absence undesirable odors and tastes of the water bodies.

Nitrates

Nitrates are the most frequently occurred water pollutants in rural areas. Nitrates generally found in traces in surface waters, but may attain high values in ground water. The permissible limit of nitrate in drinking water is 45 mg/l. High concentration of nitrate (>45mg/l) in drinking water causes a child disease known as "methemoglobinemia" or "blue baby syndrome". It is characterized by reduced ability of the blood to carry oxygen because of reduced levels of hemoglobin. In the human body nitrates are converted into nitrites which then oxidize

hemoglobin to methaemoglobin, an autocatalytic reaction¹⁰.



Thus the oxidation of iron from the ferrous state in hemoglobin to the ferric state yields methaemoglobin, which imparts a chocolate he to the blood¹¹. For individuals who suffer from anemia, cardiac failure or pulmonary disease the symptoms of hypoxia may appear at lower percentage levels of methaemoglobin. Also there are certain possible links between high nitrate consumption and certain type of cancers¹². Nitrate contamination of the ground water through out the world is a source of rising concern. In the present observation the nitrate values of the samples were found to be in the range, 3.0-87 mg/L indicating that some of the samples namely S₃ of Honnudike area (87mg/l) and samples S₂ of both Kadaba and Kallambella areas (60mg/l and 56 mg/l) have higher nitrate level than the permissible limit (Table 1) making them to be unsuitable for drinking.

Table 1: Water quality parameters

Parameters	Kadaba			Kallambella			Kunigal			Hebbur			Honnudike			WHO Stand ards	Permissible limit as per ISI
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3		
pH	7.71	7.9	7.87	8.02	8	7.98	7.8	8	8.1	7.5	8.2	7.4	7.7	7.62	7.8	6.5-9.2	6.5-8.5
EC	556	600	591	2610	2810	2260	498	920	930	825	800	816	1920	500	1918	-	-
TH(mg/L)	136	212	193	668	579	584	136	320	334	287	226	298	619	160	641	500	600
TDS(mg/L)	350	380	351	1460	1610	1340	435	550	518	480	490	495	1120	300	1154	1500	2000
DO	7.2	6.7	7.3	6.7	6.6	7.1	6.5	7.9	8.2	6.7	7.3	7.8	6.6	7	6.9	5mg/L	3mg/L
HCO3	210	190	220	746	757	352	178	282	319	269	210	278	476	240	300	-	-
Cl	47	39	39	367	448	353	64	98	76	84	75	89	65	20	292	600	1000
F-	0.63	0.39	0.52	1.34	1.23	1.61	0.32	0.24	0.18	0.34	0.29	0.32	0.63	0.38	0.81	1.5	1.5
NO3	9.1	43	38	11	40	4.5	3	20	21.6	14	14	11	40	34	87	45	45
SO4	13	40	27	164	154	330	28	82	47	63	86	71	107	1.7	199	400	400
Ca	50	66	71	66	115	118	39	101	92	53	67	65	74	46	436	200	200
Mg	3	10	9	126	68.7	72	4.9	16	32	35	14	14	54	11	78	150	100
Na	66	44	47	282	295	246	50	65	59	60	80	49	138	40	114	-	-
K	3	0.44	0.76	7	13	6.4	6	4	4.82	6	13	9.8	4	0.3	3.1	-	-
Fe	0.19	0.46	0.38	1.17	0.64	0.28	0.33	0.34	0.12	0.35	0.14	0.68	0.64	0.15	1.23	1	1

Flouridies

The permissible value of fluoride in drinking water is 1.5 mg/L (WHO). Fluoride is more common in ground water than in surface water. The sources of fluorides in ground water are fluoride-bearing rocks. In ground water, fluoride concentrations vary with the type of rock the water flows through but do not usually exceed 10mg/litre. The excess of fluoride in water causes flourosis, which depends on the climatic conditions of the area. In warmer areas, dental flourosis occurs even at lower concentrations in the drinking water. It is chiefly characterized by mottling of teeth. Long term ingestion of large amounts can also lead to skeletal flourosis, like stiffness and pain in the joints. Drinking water with level 2 ppm fluoride can disturb the functions of kidney and liver in children. Several animal studies have already shown the evidence of fluoride related kidney damage at levels as low as 1 ppm in rats and 5 ppm in monkeys¹³. It is known that persons suffering from certain forms of renal impairment have a lower margin of safety for the effects of fluoride than the average person. Fluoride along with perchlorate has been considered as an "emerging neurotoxic substance" due to its link to lower IQs in children and brain damage in animals¹⁴. The fluoride in water samples of the present study are in the range, 0.18-1.61 mg/L indicating that all samples of the study area are having the fluoride level less than the permissible limit except the samples S₃ of Kallambella area (1.67mg/L) where it has exceeded the limit (Table 1).

Chlorides

The surface and ground waters are always found to contain dissolved and suspended substances of organic and mineral origin. When disinfectants such as chlorine are added for drinking water to protect from pathogenic microorganisms, they react with naturally occurring organic matter and have been reported to form trihalomethanes (THMs), suspected carcinogens¹⁵. Chloride concentration above 100 mg/L give salty taste to water. A high level of chloride is expected to affect plants and animals¹⁶. In the present study, the chloride values of all the samples are in the range, 20-448 mg/L and within the permissible limit of WHO (Table 1).

Total hardness

In general, ground waters are harder than surface waters, the magnitude depends on geological conditions. The hardness of water is mainly due to calcium and magnesium. Though the maximum permissible value of total hardness in drinking water is 600mg/L, beyond 300 mg/L it produces gastrointestinal irritation¹⁷. The total hardness of the samples under study are ranged from 136 ,g/L to 668mg/L. The samples S₁ and S₂ of Kallambella area and samples S₃ of Honnudiike area have crossed the permissible limit whereas all other samples have hardness within the acceptable range. The highest hardness is with the samples S₂ of Kallambella area (668 mg/L) and the lowest being in samples S₁ (136mg/L) of both Kadaba and Kunigal areas (Table 1).

Cationic constituents

Iron causes staining of clothes and utensils. Some metalloids of iron, sodium, cadmium and silica in water are extermely toxic to life. Sodium and potassium both have good solubility and mobility and do not precipitate at any pH¹⁸. The concentration of iron was maximum (1.17 mg/L) in sample S₁ of Kallambella area have high sodium concentration that may create sodium hazard in the soil.

Total dissolved solids

In natural waters, the dissolved solids mainly consist of bicarbonates, carbonates, sulfates, chloride, nitrates and phosphates of calcium, magnesium, sodium and potassium with traces of iron, manganese and other minerals. The amount of dissolved solid is an important consideration in determining suitability of water for irrigation, drinking and industrial uses. In general, waters with a total dissolved solids <500 mg/l are most suitable for drinking. Higher dissolved solids may lead to impairment in physiological processes in the human body. Dissolved solids are undesirable in industrial water due to formation of scalling, accelerate, corrosion, interfere with color and tastes of many finished products. In the present study, TDS is in the range, 300-1610 mg/L. All the samples except S₂ of Kallambella area have TDS within permissible limits set by WHO making tem acceptable for drinking and irrigation. But the S₁ and S₃ samples of Kallambella

area; S₁ and S₃ samples of Honnudike area have hardness close to maximum permissible limit.

Water quality index

The quality index sample (S₁) of Hebbur and (S₂) of Kunigal area has excellent quality indicating virtual absence of threat of impairment to its quality. The quality of sample (S₂) of Kadaba area is good, implying that water quality is protected with only a minor degree of threat of impairment; conditions rarely depart from natural or desirable levels. The sample (S₂) of Kallambella area is marginal and implies that water quality is usually protected but occasionally threatened or impaired. The sample (S₁) of Honnudike area is fair, implying that water quality is frequently threatened or impaired.

CONCLUSION

The CCME WQI indicates that water

quality of sample (S₁) of Hebbur and (S₂) of Kunigal areas is excellent, that of the sample (S₁) of Kadaba area is good, that of the sample (S₂) of Kallambella area is marginal and that of the sample (S₃) of Honnudike area is fair, in 2007. In some of the samples of Kallambella and Honnudike area are having very high nitrate concentrations indicating the excess use of fertilizers, and depletion of ground water level. The waters of Kallambella area area also having more hardness making them to considered as unsuitable for many purpose.

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