The Impact of Land Use on the Surface and Groundwater Quality of Ghataprabha Subbasin

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Abstract
Human activities have modified the environment for thousands of years. Land use and agriculture play a vital role in sustaining the health, nourishment and economy of the world's population. At the same time, some land use practices can degrade the quality of our soils, waterways, air and other natural resources. Ghataprabha river is one of the major and important river in Kolhapur (Maharashtra) and Belgaum (Karnataka) districts, which has undergone tremendous changes over the last 15–20 years. Therefore, it is essential to know the impact of land use on water quality (both on surface and groundwater). In the present study an attempt is made to monitor the surface and groundwater water quality parameters to determine the impact of land use on the surface and groundwater quality of Ghataprabha Subbasin. *Water sampling was done both in the surface water of river and the groundwater sources near the river. The water samples were analyzed for pH, total dissolved solids (TDS), electrical conductivity (EC), dissolved oxygen (DO), sulphates, chloride, bicarbonates, nitrates, phosphates, fluoride, sodium, potassium* using the standard methods recommended in the manuals (APHA, 2005). *Land uses in the area significantly affected the concentration of EC, TDS, sulphates, potassium and sodium while pH, dissolved oxygen, chloride, bicarbonates, nitrates, phosphates did not significantly fluctuate with land use changes in the area.* To minimize the destruction of hydro-systems and the degradation of their water quality due to land use, multidisciplinary studies are required at the design stage of the project, and *an integrated water resources management approach where all users should take an active role in the conservation of Ghataprabha River catchment in order to avoid further degradation of the catchment through different land uses.*
Keywords: River Ghataprabha, physicochemical parameters, land use changes, pollution

1. Introduction

Land use has generally been considered a local environmental issue, but it is becoming a force of global importance. Worldwide changes to forests, farmlands, waterways, and air are being driven by the need to provide food, water, and shelter to more than six billion people. Global croplands, pastures, plantations, and urban areas have expanded in recent decades, accompanied by large increases in energy, water, and fertilizer consumption, along with considerable losses of biodiversity. Such changes in land use have enabled humans to appropriate an increasing share of the planet's resources, but they also potentially undermine the capacity of ecosystems to sustain food production, maintain freshwater and forest resources, regulate climate and air quality, and ameliorate infectious diseases. We face the challenge of managing trade-offs between immediate human needs and maintaining the capacity of the biosphere to provide goods and services in the long term.

The quality of surface waters is often affected by heavy sediment loads and turbidity levels, particularly in rivers and lakes following high intensity rainfall. This naturally occurring problem is made worse by human activity, such as uncontrolled land cleaning for agriculture, which causes additional sediment loads to be transported into river systems. High sediment load cause problems such as the blockage of river or lake intakes for water supply. The rising salinity of ground water used for water supply and irrigation is a major problem. There are many examples of salinity increases due to seawater intrusion as a result of over pumping of fresh water lessens. This is generally caused by localized over pumping from wells, boreholes and infiltration galleries. In other cases, the problem is far more widespread and severe and is caused by general over-abstraction from many different systems.

2. Study Area

Ghataprabha sub basin catchment was selected as the study site, located in the Krishna river basin, India. The catchment of the basin lies approximately between the northern latitudes 15° 45' and 16° 25' and eastern longitudes 74° 00' and 75° 55'. The river basin is 8,829 square kilometers wide and stretches across Karnataka and Maharashtra states. The river Ghataprabha rises from the Western Ghats in Maharashtra at an altitude of 884m, flows eastward for 60 Km through the Sindhudurg and Kolhapur districts of Maharashtra, forms the border between Maharashtra and Karnataka for 8 Km and then enters Karnataka. Tamraparni River is a tributary of river Ghataprabha joins the main stream at Daddi. A dam has been constructed at Hidkal (which is about 20-25 km from Daddi) in Hukkeri taluk (Belgaum district, Karnataka, India) to impound 2200 Mm^3 of water for supplying to adjoining taluks for irrigation purpose. The basin catchment was selected as the study site for several reasons. It was experiencing water quality problems due to nonpoint source pollutions from intensive farming practices, road construction, and mining extraction. Thus, there was a high conservation need for water quality protection.

2.1 Land Use Pattern

Land use pattern is an important aspect for determining the various hydrological phenomena like infiltration, overland flow, evaporation and interception. Land use pattern has significant influence on the quality and quantity of runoff available from it. The spatial distribution of land use in Ghataprabha representative subbasin is shown in Figure 1 and Table 1), which reveals that there are four different types of land uses in the Ghataprabha representative basin. These are: Agriculture land, barren/fallow land, shrubs and forests.

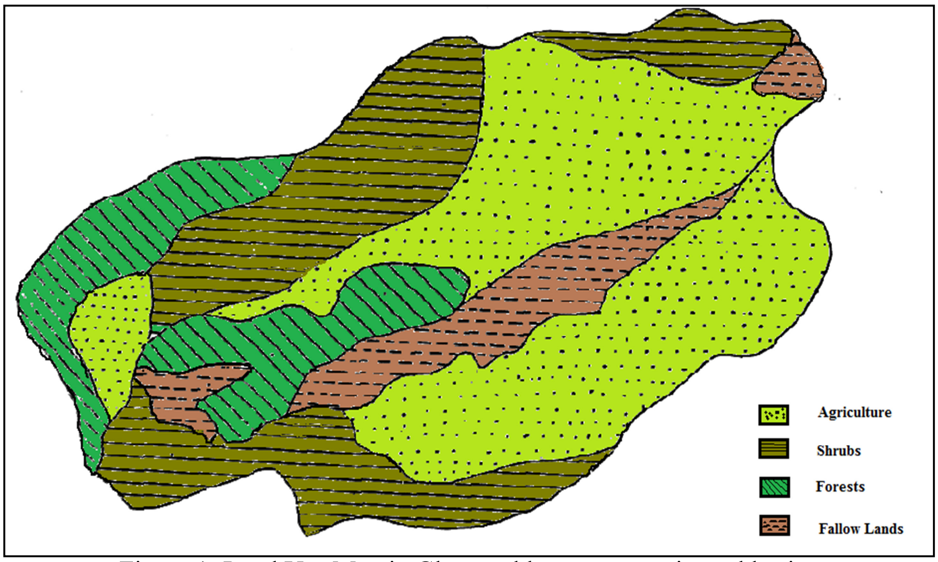

Figure 1: Land Use Map in Ghataprabha representative subbasin

Table 1: Distribution of area under different land use type in Ghataprabha representative sub-basin

Land use type	Area (Km^2)	Area (%)
Forests	145.6	13.8
Shrubs	369.7	35.05
Fallow lands	88.08	8.35
Agricultural land	451.56	42.80
Total	1055.0	100.0

3. Materials and Methodology

For assessing physico-chemical characteristics, samples were collected from all the sampling stations in the month of February 2014. Depending upon the location of point sources of waste discharges, eight sampling stations were selected, along the stretch of the river and thirteen Groundwater samples were collected from various points based on land use and agriculture pattern. For a sample of water to be the true representative of water quality, water must be well mixed. Therefore a due care was taken in selecting the distances between each sampling station so that the maximum mixing of the waste discharge with the river water ensured the true water quality of the river. The river stretch selected for the study of surface water quality along with location of villages on the bank of the river is shown in Table 2, Table 3 and Figure 2. And Groundwater sampling stations nearby river are shown in Table 4 and Figure 3.

Table 2: Surface Water Location Sites of Ghataprabha stretch.

Code	Station name	Reach length (km)	Longitude	Latitude
S3	Adkur	0	16° 0'31.59"N	74°16'7.17"E
S4	Tarewadi	14.9	16° 3'15.55"N	74°21'8.82"E
S7	Daddi	11.3	16° 3'27.69"N	74°26'5.63"E
S8	Benkoli	11.6	16° 4'13.33"N	74°31'18.50"E

Table 3: Surface Water Location Sites of Tamraparni stretch.

Code	Station name	Reach length (km)	Longitude	Latitude
S1	Chandgad	0	15°55'59.32"N	74°11'5.42"E
S2	Halkarni	22.5	15°54'57.52"N	74°17'39.14"E
S5	Kowad	12.5	15°59'12.68"N	74°22'48.09"E
S6	Dundage	8.8	16° 0'7.80"N	74°23'32.50"E

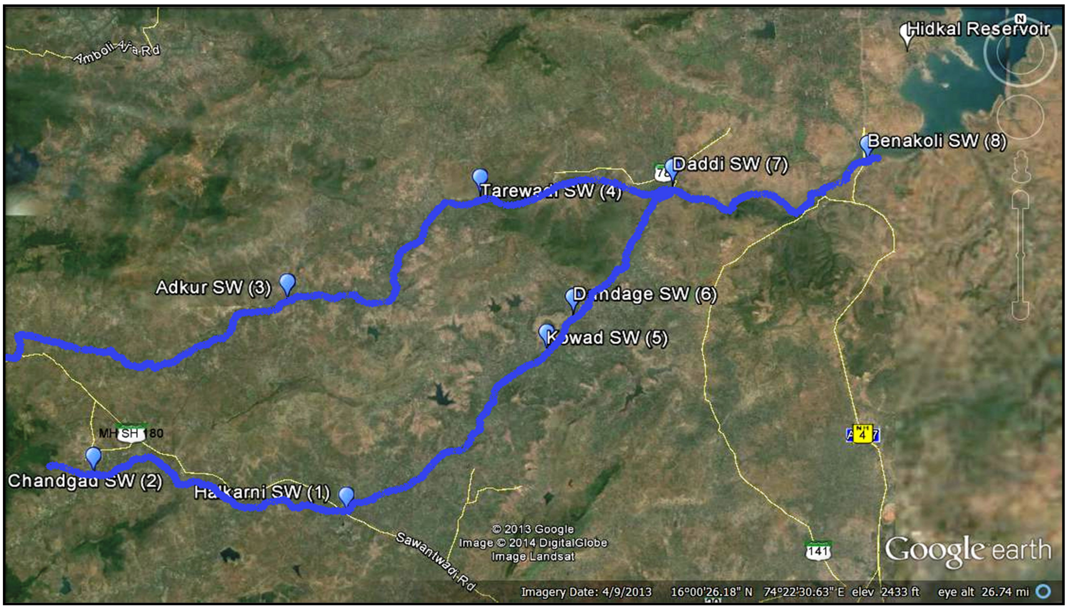

Figure: 2 Surface Water Location Sites

Table 4: Ground Water Location Sites.

Code.	Station name	Depth (m)	Longitude	Latitude
G1	Halkarni OW (Agricultural field)	1.4	15°55'6.93"N	74°17'30.05"E
G2	Halkarni BW (Beside main road)	-	15°55'14.70"N	74°17'15.46"E
G3	Chandgad OW (Farm House)	7	15°55'55.19"N	74°11'8.25"E
G4	Chandgad BW (School)	-	15°56'38.05"N	74°11'8.82"E
G5	Chandgad BW (Tea stall)	-	15°56'36.58"N	74°11'9.38"E
G6	Adkur BW (Opposite to Ultratech)	-	16° 0'43.81"N	74°16'3.73"E
G7	Nesri BW (Public Water tank)	-	16° 3'41.25"N	74°19'42.90"E
G8	Kowad OW (Agricultural field)	2.6	15°59'16.70"N	74°22'55.91"E
G9	Dundage OW (Farm House)	1.6	16° 0'12.54"N	74°23'29.03"E
G10	Chennatti BW (School)	-	16° 1'19.83"N	74°24'35.39"E
G11	Daddi OW (Bank of the River)	2.8	16° 3'26.64"N	74°26'18.01"E
G12	Daddi BW (House opp. to School)	-	16° 4'1.79"N	74°26'15.79"E
G13	Benkoli OW(Agricultural field)	6.1	16° 4'53.51"N	74°30'41.42"E

Figure 3: Ground Water Location Sites

In the present study, at each sampling station, chemical parameters such as, pH, Electrical Conductivity, Total Dissolved Solids, Chlorides, DO, BOD, etc were determined using the Standard Methods recommended in the manuals (APHA, 2005)

4. Results and Discussion

In the present investigation eight surfaces and thirteen groundwater samples were analyzed during the month of Feb 2014. The results of the surface and ground water quality of Ghataprabha subbasin are analyzed and the various water quality parameters determined for the surface water samples and groundwater samples were given in Tables 5, 6, and 7, 8 respectively. And variations of the water quality parameters at various locations are shown in Figures 4, 5 and 6.

Table 5: Surface water quality parameters observed at Tamraparni Stretch.

Sl. No	Parameter	Halkarni (S1)	Chandgad (S2)	Kowad (S5)	Dundage (S6)
1	pH	6.8	6.39	6.36	6.77
2	Turbidity, NTU	8.1	7.7	7.6	5.7
3	Conductivity in µS/cm	85	86.3	135.4	206.9
4	TDS, mg/L,	39.7	40.7	64.6	98.3
5	Chloride, mg/L,	13.87	14.893	18.13	22.31
6	T.H, mg/L as CaCo3	22	18	44	76
7	Ca, mg/L	4.21	6.73	12.62	20.19
8	Mg,mg/L	2.92	0.49	3.4	6.81
9	T.A, mg/L,	42	34	32	41
10	Na, mg/L,	10.9	13.8	13.8	18.3
11	K, mg/L,	1.3	1.3	1.7	3
12	D.O, mg/L	5.71	7.1	6.01	6.5
13	BOD_5, mg/L,	2.9	2.0	2.3	2.2
14	Nitrates	11	7	9.5	10.7
15	SO_4, mg/L	5.75	2.5	5.75	5.5
16	PO_4, mg/L,	3.6	2.2	5.25	4.2
17	Fluoride	0.2	0.3	0.4	0.4

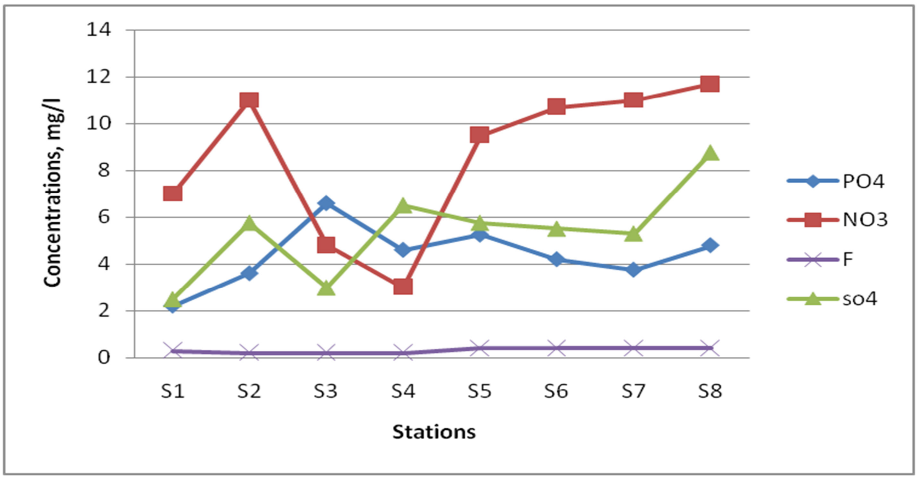

Figure 4: Variations of Phospates, Nitrates, Fluroide and Sulphates in various Surface water locations

Table 6: Surface water quality parameters observed at Ghataprabha stretch.

Sl. No	Parameter	Adakur (S3)	Tarewadi (S4)	Daddi (S7)	Benkoli (S8)
1	pH	6.61	7.09	6.92	7.16
2	Turbidity, NTU	2.8	4.5	4.6	7.2
3	Conductivity in µS/cm	62.2	91.8	136.4	255
4	TDS, mg/L,	29.3	43.3	64.5	121.4
5	Chloride, mg/L,	5.42	8.933	20.865	32.34
6	T.H, mg/L as CaCo3	22	32	46	82
7	Ca	7.57	8.41	12.62	31.12
8	Mg	0.97	2.92	3.89	1.94
9	T.A, mg/L,	28	38	37.08	38.34
10	Na, mg/L,	7.7	11.8	16	26.7
11	K, mg/L,	0.7	1.3	2.6	2.8
12	D.O, mg/L	7.3	6.1	6.7	7.88
13	BOD_5, mg/L,	1.4	2.6	2.3	1.2
14	Nitrates	4.8	3	11	11.7
15	SO_4, mg/L	3	6.5	5.3	8.75
16	PO_4, mg/L,	6.6	4.6	3.75	4.8
17	Fluoride	0.2	0.2	0.4	0.4

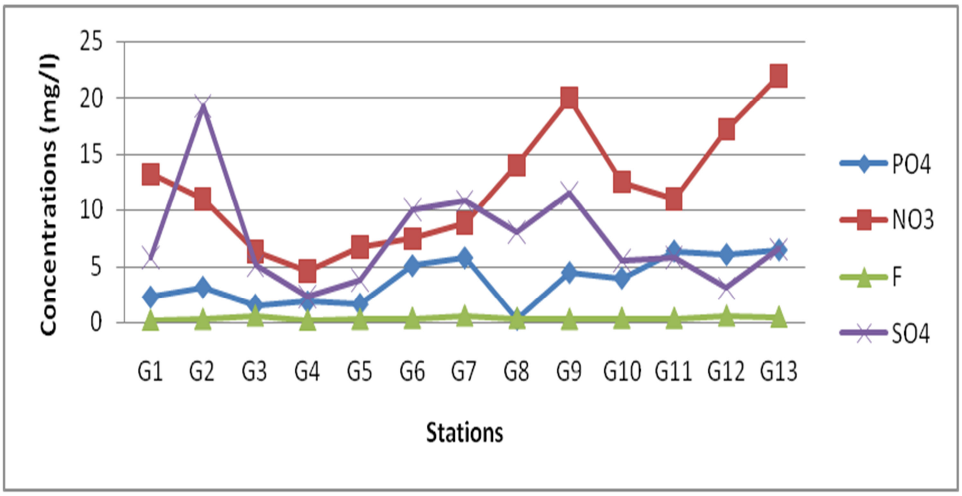

Figure 5: Variations of Phospates, Nitrates, Fluroide and Sulphates in various Groundwater locations

Table 7: Ground water Quality parameters observed at Tamraparni stretch.

Sl.	Parameter	Halkarni		Chandgad			Kowad	Dundage	Chennatti	BIS specification for Drinking water IS 10500-1991
		OW (G1)	BW (G2)	OW (G3)	BW (G4)	BW (G5)	OW (G8)	OW (G9)	BW (G10)	Desirable Limit
1	pH	6.15	6.28	5.98	5.93	6.02	6.14	6.23	6.16	6.5 to 8.5
2	EC in µS/cm	146.2	251	72.6	86.8	92.1	316	373	197.7	-
3	TDS, mg/L,	69.2	119.3	34.1	40.9	43.1	151.5	179.3	94.0	-
4	Chloride, mg/L,	2.85	5.74	3.65	3.96	2.42	4.23	5.36	4.91	250
5	TH,mg/L	48	92	24	26	20	74	112	46	300
6	Ca,mg/L	13.46	29.4	5.89	6.73	7.57	30.28	17.66	15.98	75
7	Mg mg/L	3.89	5.35	2.43	2.43	0.49	0.49	7.29	1.94	-
8	T.A, mg/L,	44	74	36	28	40	43.92	73.41	44.07	200
9	Na, mg/L,	14.1	27.8	9.7	10.9	13.8	22.4	29.1	26.8	-
10	K, mg/L,	0.6	1.3	1.6	0.6	1.0	4.1	6.4	6.8	-
11	Nitrates,mg/L	13.2	11.0	6.3	4.5	6.7	14	20	12.5	45
12	SO_4, mg/L	5.75	19.25	5	2.25	3.75	8	11.5	5.5	200
13	PO_4, mg/L,	2.23	3.1	1.5	1.8	1.6	0.25	4.4	3.9	-
14	Fluoride,mg/L	0.2	0.3	0.6	0.2	0.3	0.4	0.3	0.4	1.0

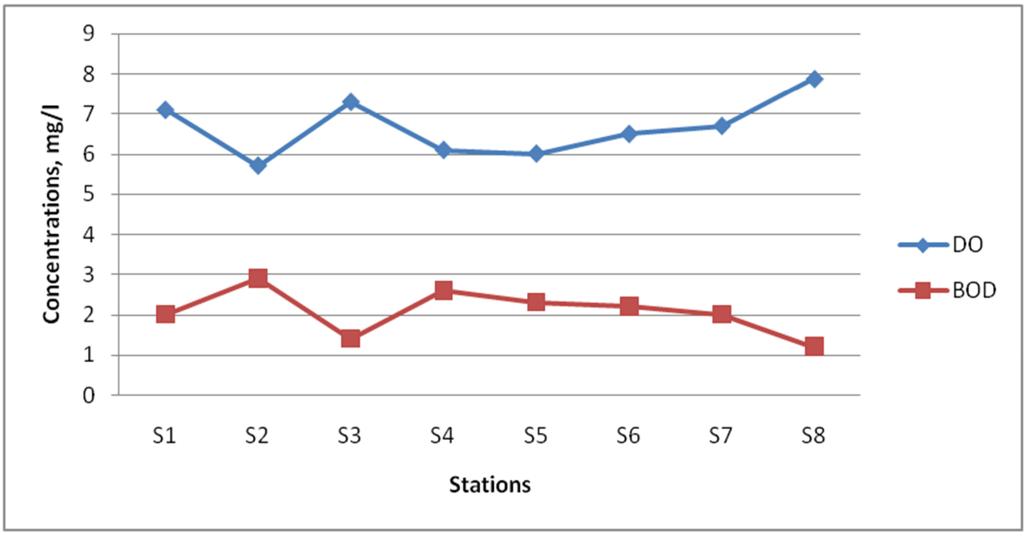

Figure 6: Variation of DO and BOD in various Surface water locations

Table 8: Ground water Quality parameters observed at Ghataprabha stretch.

Sl.	Parameter	Adakur	Nesri	Daddi		Benkoli	BIS specification for Drinking water IS 10500-1991
		BW (G6)	BW (G7)	OW (G11)	BW (G12)	OW (G13)	Desirable Limit
1	pH	7.08	6.74	6.18	5.98	5.55	6.5 to 8.5
2	EC in µS/cm	306	295	165.9	223	242	-
3	TDS, mg/L,	146.7	141.1	78.5	106.3	115.8	-
4	Chloride, mg/L,	10.91	6.3	3.56	5.41	6.81	250
5	TH,mg/L	74	80	46	52	54	300
6	Ca,mg/L	21.87	20.19	10.93	15.14	21.03	75
7	Mg mg/L	5.35	7.87	4.86	3.89	0.97	-
8	T.A, mg/L,	108	56	54	30	24	200
9	Na, mg/L,	60.5	34.8	19.5	28.1	37.8	-
10	K, mg/L,	3.3	5.7	0.7	8.2	5.1	-
11	Nitrates,mg/L	7.4	8.8	11.0	17.2	22	45
12	SO_4, mg/L	10	10.75	5.75	3	6.5	200
13	PO_4, mg/L,	5	5.7	6.3	6	6.4	-
14	Fluoride,mg/L	0.4	0.6	0.4	0.6	0.5	1.0

From the analyzed results it was found that the quality of water considerably varies from location to location. In the surface water of Ghataprabha sub-basin, pH values are mostly confined within the range between 6.36 and 7.16. In groundwater it ranges from 5.55 to 7.08. The maximum pH values are observed in Bore wells. Groundwater quality shows an acidic behavior in some of the wells which could be due to the laterite soils present in the catchment areas. Conductance of water samples varied from 255 µS/cm to 62.2 µS/cm in surface water and 373 µS/cm to 72.6 µS/cm in ground water and hence suitable for irrigation purpose. The TDS content in the study area observed in the surface water varied from 29.3 mg/l to 121.4 mg/l. In ground water the TDS varied between 34.1 mg/l to 151.5 mg/l indicating the suitability of water for all purposes. The total hardness in surface water ranged from minimum 18 mg/l in Chandgad (S1) to maximum of 82 mg/l in Benkoli (S8). In Ground water TH ranged from 20 mg/l in Chandgad (G5) to 112 mg/l in Dundage (G9). In surface water the concentration of DO varies from 5.71 mg/l in Halkarni (S2) to 7.88mg/l in Benkoli (S8). In Halkarni (S2) minimum DO is observed which could be attributed to mixing of wastes from sugar industry with the surface water. In the present study BOD value was minimum in Benkoli (S8) with 1.4 mg/l and maximum in Halkarni (S2) with 2.9 mg/l, indicating the traces of organic pollution. In surface water the concentration of sodium ranges from 7.7 mg/l in Kowad (S3) to 26.7 mg/l in Benkoli (S8). The concentration of potassium varies from 0.7 mg/l in Kowad (S3) to 3 mg/l in Dundage (S6). In ground water sodium ranged from minimum 9.7 mg/l in Chandagad (G3) to maximum 60.5 mg/l in Adkur (G6). The concentration of potassium in groundwater ranged from 0.6 mg/l in Chandgad (G1) and Halkarni (G4) to 8.2 mg/l in Daddi (G12). The higher sodium concentration is observed in the study area is due to the application of excessive fertilizers. Nitrate in surface water it ranged from 3 mg/l in Tarewadi (S4) to 11.7 mg/l in Benkoli (S8) and in groundwater it varied from 4.5 mg/l in Chandgad (G4) to 22 mg/l in Benkoli (G13). In surface water phosphate varies from 2.2 mg/l in Chandgad (S1) to maximum of 6.6 mg/l in Adkur (S3) and in ground water it varied from 0.25 mg/l in Kowad (G8) to 6.4 mg/l in Benkoli (G13). Concentration of sulphate in surface water ranged from 2.5 mg/l in Chandgad (S1) to 8.75 mg/L in Benkoli (S8), and in groundwater it varied from 2.25 mg/l in Chandgad (G4) to 19.25 mg/l in Halkarni (G2). According to the National Sanitation Foundation Water Quality Index, surface water quality of overall Ghataprabha subbasin was mainly assessed as medium quality since the values ranged from 56 to 67.

Geochemical and Irrigational Water Quality Classification were analyzed for the groundwater of Ghataprabha subbasin. The Piper diagram is the most widely used graphical form for geochemical classification. It is found that during the study period, the most dominating class is Mixed $CaNaHCO_3$ (61.54%). Apart from said group, two secondary set of clusters are found which are dominated by $CaHCO_3$ (23.07%) and $NaHCO_3$, (15.38%). The Figure 7 reveals the analogies, dissimilarities and different type of waters in the study area.

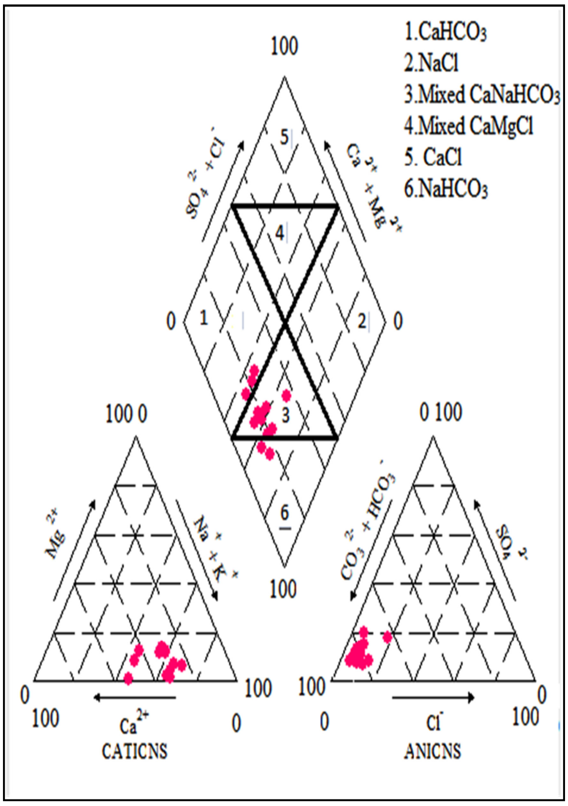

Figure 7: Piper Trilinear Classification of Groundwater Samples

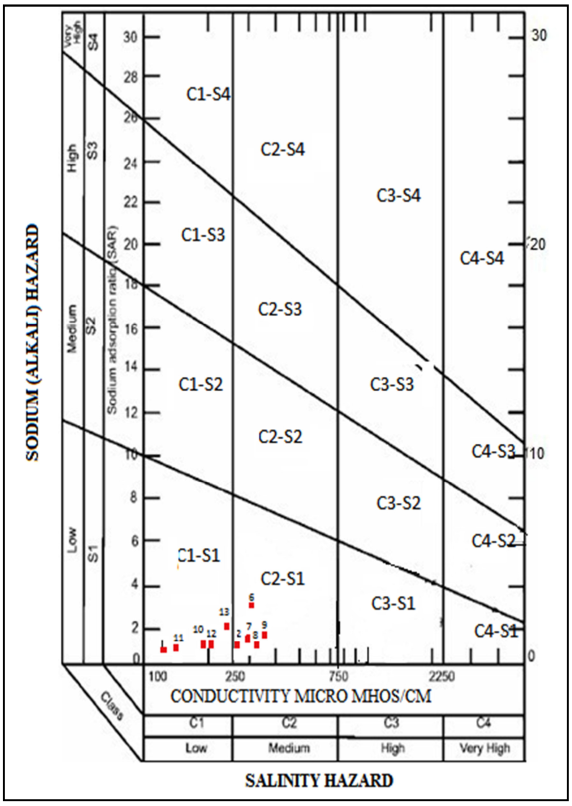

Figure 8: U.S. Salinity Classifications of Groundwater Samples.

As per U.S. Salinity Laboratory Classification, the Figure 8 reveals that, 50% of the samples fall under the fields of C1-S1 and 50% under C2-S1 during the study period. According to this the groundwater samples of the Ghataprabha subbasin under study, belongs to low salinity to medium salinity and low sodium category. To evaluate the suitability of water for irrigational purposes, The Sodium Adsorption Ratio was analyzed. The values in the study area range from 0.871 to 3.007. The values are less than 10, it indicates that the water of the study area belongs to excellent category and is free from sodium hazards. The Sodium Soluble Percentage (SSP) was calculated as per Todd's method. The values of percent sodium in this study area range from 38.79% to 63.94%. Thus, 85% of the samples are good and permissible for irrigation purpose.

5. Conclusions and Recommendations

Our study focuses on the effect of land use on water quality in the study area. The observed water quality parameters in both surface and groundwater of Ghataprabha representative subbasin are well within the permissible limit of drinking, irrigation and all other domestic and recreational purposes. There are indications of sulphate enrichment in ground waters due to excessive applications of fertilizers, which is attributed to high recharging capacity of soils in such locations. The reason for higher representation of chemical constituents at downstream is also attributed to river damming, which can also greatly modify water quality through particle settling and evaporation. At the outset, the study revealed that there are additions of large quantities of effluents due to base flow and irrigation return flow. The impact of various outfalls such as sugar mill drain, municipal or village sewage outlets and industrial drains on the river shows a slight decrease in Dissolved Oxygen at the downstream along the course of both Tamraparni and Ghataprabha Rivers. The two rivers join at Daddi where there is an improvement of water quality due to dilution effect of stored water in Hidkal Reservoir. However the river has a high self purification capacity due to which impact is less. The developmental activities in the study area are leading to the habitat destruction. In general streams and rivers are strongly affected by anthropogenic activities like agriculture expansion, changing crop pattern from traditional food crops to sugarcane leads to rapid change in agriculture pattern and land use, urbanization, industrialization, pollution, construction of Hidkal dam, mining activities are the threats with varying impacts aggravating the current situation of environmental decline in the Ghataprabha subbasin. Thus Land uses in the area affects the water quality of Surface and

Groundwater in the Ghataprabha subbasin.

From the physical standpoint, it is understood that knowledge on impact of land use and cropping pattern on water quality is essential part of hydrological cycle. Mathematical models suitable for making accurate computerized projections of long-term movement of chemicals in the environment under different circumstances are needed. It is important to note that the water management projects can significantly change water quality in negative way. To minimize the destruction of hydro-systems and the degradation of their water quality, multidisciplinary studies are required at the design stage of the project, and at each step continue for several years to make certain decision that suitable management can be assured.

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