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Spatial Analysis of Water Quality Parameters in River Teesta Using Arc-GIS, East Sikkim, India

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Abstract - *River water is an important source of water for irrigation and also for agriculture use. It is also a major source for fishes and other aquatic organisms as it serves as a habitat for them. Now days water in river are facing threats due to anthropogenic activities. The present study focused on application of GIS for graph for spatial distribution of important water quality parameters of Teesta River which flows through East Sikkim. A total of nine water sampling locations were selected for the study and some physico-chemical parameters were recorded using standard methods. It was found in this study that some sampling station like Singtam, Majhitar and Rangpo showed high concentration of pH (i.e. acidic nature). The other parameters like conductivity, Hardness and TDS showed a increasing trend which has a direct affect on the water quality. Also maps were made using Inverse Distance Weighted (IDW) tool off Arc-Gis to know the Spatial variation of physico-chemical parameters along the river. The map shows four Classes of classification of parameters: Low, Medium, High and Very High.*

Key Words: **East Sikkim, Teesta River, Spatial distribution, Physico-Chemical Parameters, IDW, Arc-Gis.**

1. INTRODUCTION

Most human activities involve the use of water in one way or other. It may be noted that man's early habitation and civilization sprang up along the banks of rivers. Although the surface of our planet is nearly 71% water, only 3% of it is fresh. Of these 3% about 75% is tied up in glaciers and polar icebergs, 24% in groundwater and 1% is available. Due to increasing industrialization on one hand and exploding population on the other, the demands of water supply have been increasing tremendously. The indices are among the most effective ways to communicate the information on water quality. Water Pollution is one of the most serious problems to humankind. It is an established fact that water quality is closely related to the surrounding environment and prevalent land use (APHA, 1992). Water is a chemical compound with the chemical formula H_2O. Water covers 71% of the Earth's surface (CIA, 2014) and is vital for all known forms of life.

GIS is an important tool for Water Quality Mapping and essential for monitoring environmental change. In this work Arc-GIS has been used as a major tool mapping the spatial distribution of water Quality parameters along Teesta River in East Sikkim The use of GIS has simplified the assessment of Natural resource and environmental concerns, including surface water quality.

The physico-chemical parameters like pH, turbidity, BOD, Conductivity, Hardness, Alkalinity, TDS, Chloride and Calcium has been mapped using IDW tool of Arc-GIS by downloading DEM from "Bhuwan" website.

2. RELATED WORK

Many related work have been done using GIS technique for mapping of pHYsico-chemical parameters using GIS for both ground water and for surface water, but majority of mapping have been done for ground water using IDW tool of Arc-Gis. Some of the work like mapping statial distribution of Water Quality using GIS in ground water of kelani river basin has been done by M.G.Y Mahagamage ans et al. Work on spatial distribution of Water Quality for determining the effect of coal ming in Meghalaya has also been done by Lamshuk Nongtdu as a Mtechproject work. River water Spatial distribution of Water Quality parameters in the form of Contour Maps has also been done by N. Gajendran for Nambiyar basin in Tamilnadu, India.

3. MATERIALS AND METHOD

3.1 STUDY AREA

Teesta River is one of the major river in Sikkim (27^{5}' N to 20^{9}'N latitudes and 87^{5}9' E to 88^{5}6'E) with 60 km length, originates from Zemu Glacier(Tsholamu Lake) in the Northen Disrict at an elevation of 8580 m above mean sea level. The river flows through the thickly populated area of the city of Gangtok, Singtam, Rangpo. The potentially polluted stretch of the river is within the Gangtok Municipality area for a length of about 30 kms. The people inhabiting around this river uses the partially treated water for agricultural, drinking and washing purposes. Based on the importance of this freshwater body towards

human livelihood, aquatic biodiversity, aquaculture, agriculture assessment of water quality index is very much required. The study area map of Teesta River has been shown on figure 1 below:

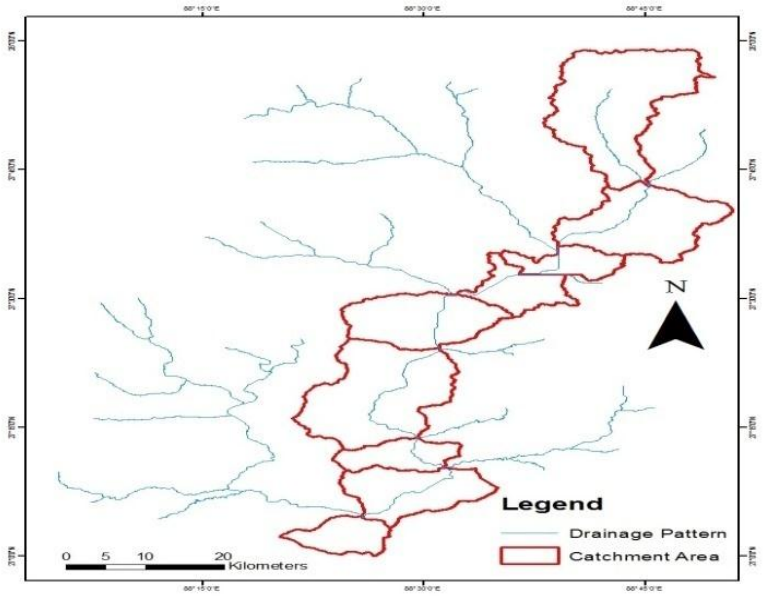


Figure 1: Study area map

3.2 SAMPLING SITES

The details of the sampling station along with the geographic location coordinates are tabulated below:

Table -1: Details of Sampling stations along with geographical coordinates

Sl. no.	Sampling stations	Latitude	Longitude	Remark
1	Burtuk	27°35'40''N	88°61'58'' E	City Area
2	Adampool	27°30'69''N	88°58'48''E	Outskirt area
3	Sangkhola	27°24'93''N	88°52'96''E	Village Area
4	32 number	27°26'29''N	88°56'59''E	Industrial Area
5	Martam	27°26'20''N	88°55'56''E	Village Area
6	Singtam	27°13'64''N	88°39'31''E	City Area+Industrial area
7	Bardang	27°21'62''N	88°43'06''E	City Area
8	Majhitar	27°18'76''N	88°49'97''E	Densely populated +industrial area
9	Rangpo	27°17'61''N	88°52'87''E	City Area

The samples are collected in two months i.e. June and October 2018 from the above mentioned sampling stations. Water samples are collected by using plastic bottle from study site of Teesta River. Parameter like water temperature was taken on the spot using digital thermometer. pH of water was measured by pH meter. Turbidity or transparency of water was taken by turbidity meter, total alkalinity; BOD and total hardness are determined by titration method (APHA, 2005). The Dissolved

Oxygen determination was done by Wrinkler's method with Azide modification (APHA, 2005). The elements like calcium, magnesium and chloride are analysed by titration method (ALPHA, 2005)

3.3 SPATIAL DISTRIBUTION OF PARAMETERS:

The spatial distribution of Water Quality parameters was done after determination of Water Quality Index of the River Teesta. The details of the parameters are as tabulate below in Table 3 and Table 4.

Table -2: Physico-Chemical parameter data for the month of June

SITES									
PARAMETERS	S1	S2	S3	S4	S5	S6	S7	S8	S9
pH	8.5	7.5	7	6.2	8	6	6	5.9	5.7
Turbidity	140	130	160	160	155	170	164	170	160
D.O	13	16.2	19.2	21	20	22	22	25	23
B.O.D	6.5	8.5	10	16	12	14	12	18	15
Conductivity	280	235	240	260.8	220	200	240	260	240
Hardness	80	85	85	99	82	98	85	110	110
Alkalinity	100	102	102	110	102	102	108	110	110
T.D.S	120	110	140	170	150	180	120	140	120
Chloride	30	30	35	40	30	32	30	40	38
Calcium	32	32	36	36	36	20	30	35	30

Table -3: Physico-Chemical parameter data for the month of June

SITES									
PARAMETERS	S1	S2	S3	S4	S5	S6	S7	S8	S9
pH	7.5	7.2	7.2	6.5	8.5	6.28	6.8	6.0	6.2
Turbidity	100	120	155	125	120	130	140	150	160
D.O	15	18	23	21	25	26	20	25	23
B.O.D	8.5	10	12	8	8	18	10	12	17
Conductivity	300	250	250	220	200	200	200	210	260
Hardness	100	87	89	82	82	100	100	100	100
Alkalinity	120	80	80	72	79	80	80	120	130
T.D.S	130	170	170	130	140	140	110	100	140
Chloride	30	26.4	30	60	40	25.58	35	30	35
Calcium	35	34	32	32	32	17.2	36	40	32

3.4. RESULTS AND CONCLUSION

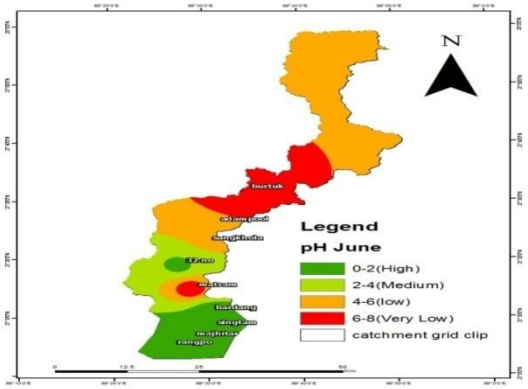
The details of the physico-chemical which were sampled in the laboratory of the State Pollution Control Board, Sikkim for the month of June and October 2018. The data provided in Table3 and Table 4 which were used for mapping the Spatial Distribution map using IDW tool of Arc-Gis.

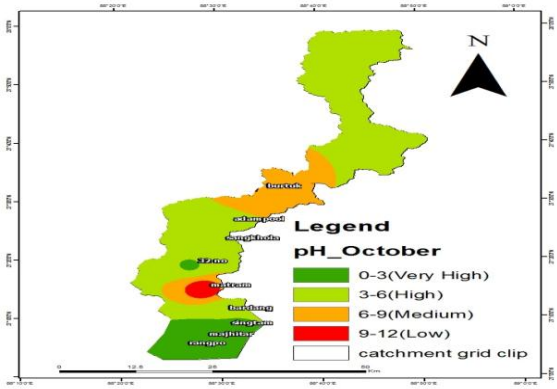
According to the data tabulated in Table3 and Table 4above, Spatial distribution map of physico-chemical parameters were mapped for the month of June and October 2018 using Inverse Weighted Tool (IDW) of Arc-Gis. For theprocess of mapping , a Digital Elevation Model (DEM) was downloaded for "Bhuwan" for the state of Sikkim and data of the physico-chemical parameters were uploaded to map the water quality parameters. The Figure below the the map for the month of June and October 2018:

i) pH:

The figure below shows two spatial map case for pH, Case(i) for the month of June whereas Case(ii) for the month of October 2018 respectively. It is seen that in June season pH ranges from acidic to basic. Acidic pH(0-6) can be observed in 32no, Martam, Bardang, Singtam, Majhitar and Rangpo . The area such as Burtuk, Adampool, Sangkhola lies in the zone of low pH (7-8).

For the month of October pH is noticed high (i.e acidic) in same places as in June ie. Singtam, Bardang, Majhitar and Rangpo whith the pH value nearly equal to the value for June. The reason for both the cases may be due to the industrial belt that lies in those region whose direct outlet affects the river Water Quality.



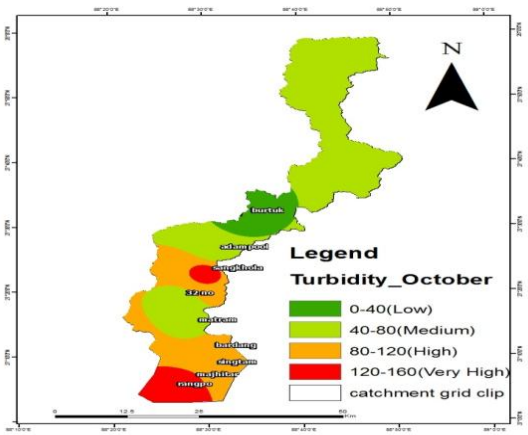


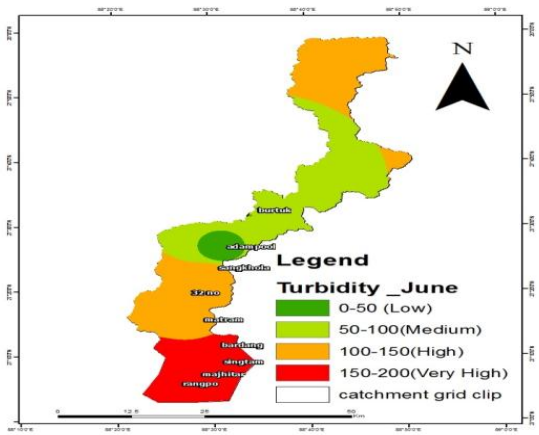
Case(i) pH- June -2018 Case(ii) pH-October-2018

Fig-1: Spatial Distribution map of pH

ii) Turbidity:

The value of turbidity for the month of June and October is tabulated in table 1 and table 2 respectively. The Turbidity value ranges from 130-170 NTU and 100-160 NTU for the month of June and October respectively. The reasom for High turbidity in June may be due to heavy rainfall. The spatial map has been constructed to represent turbidity as case(i) and case(ii).The Turbidty value for the month of October is quite low when compared to the data for June as in October which may be due to lower intensity of rainfall causing less erosion.



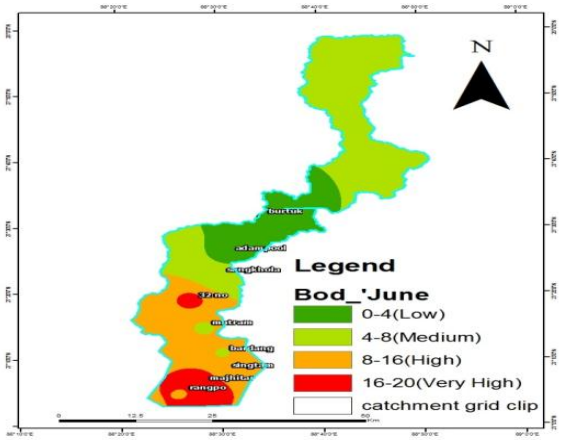


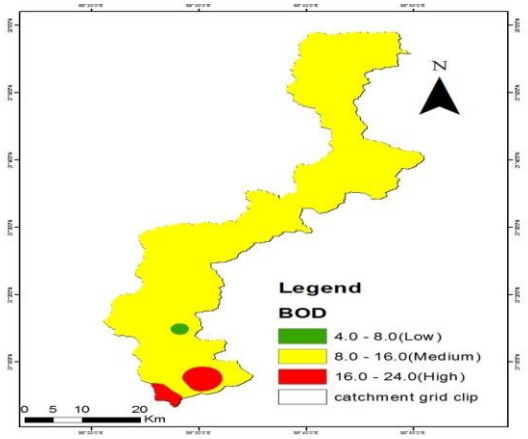
Case(i) Turbidity-June-2018 Case(ii) Turbidity-October-2018

Fig-2: Spatial Distribution Map of Turbidity

iii) Biological Oxygen Demand:

The data of biological demand ranges from 6.5-18mg/L and 8-16 mg/L for the month of June and October respectively. The BOD is the main constituent for river because it serves as a food for the microbial organisms in water. In the figure below case(i) and case(ii) represents the Spatial map for June and October. We can see that the area such as 32no, Majhitar and Rangpo falls under high BOD area. Though the BOD value is exceeding the permissible standard given by IS standard but when compared to others river data quality of India this river data for BOD is very low indicating it is not a major parameter for water quality degradation.



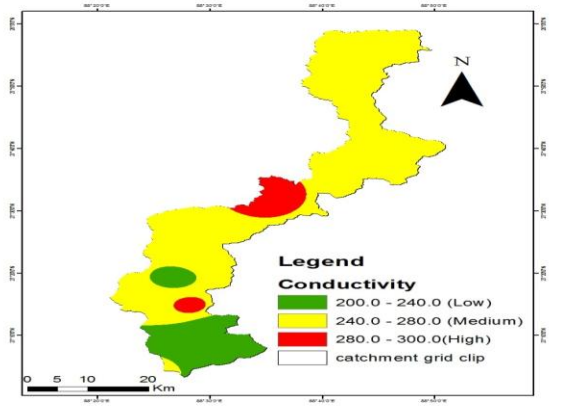


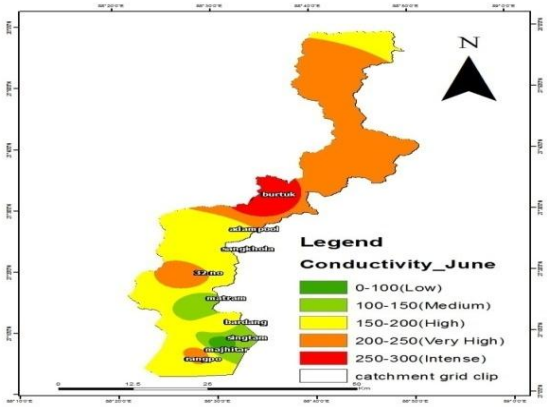
Case(i)BOD-June-2018 Case(ii) BOD-October 2018

Fig-3: Spatial Distribution Map of BOD

iv) Conductivity:

The conductivity ranges from 200-280µS/cm and 200-300µS/cm for the month of June and October respectively. The high values of conductivity can be observed in Burtuk Bardang and Majhitar in June and in Burtuk in October The reason for high Conductivity ,may be due to chemical outlet from the hospitals and for Burtuk and may be due to the presence of Industries in Bardang and Majihtar. The spatial map for the month of June and October is shown Figure 4 case (i) and case (ii) repectively. The data for Conductivity when compared with June increased in some of the areas while it decreased in certain areas.



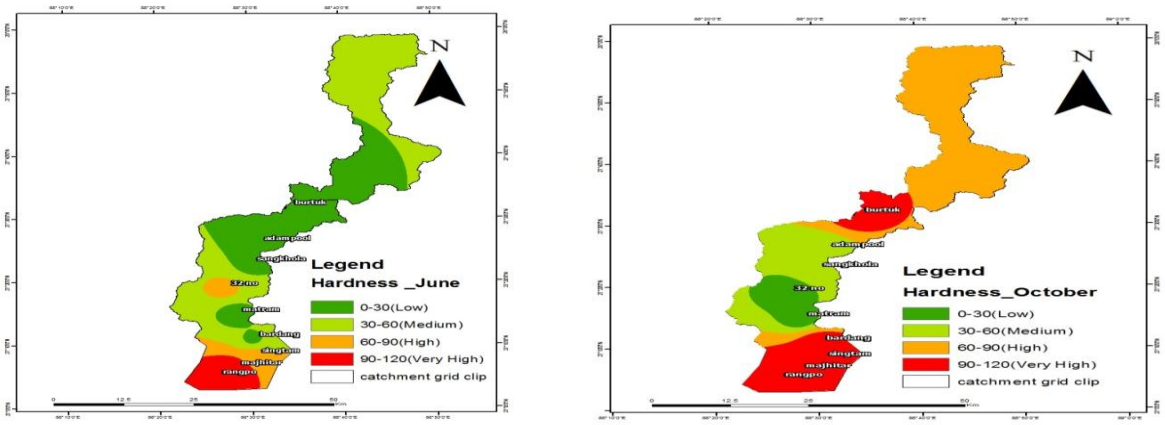


Case(i)Conductivity June-2018 Case(ii) Conductivity-June-2018

Fig-4: Spatial Distribution map of Conductivity

v) Hardness:

The hardness level in the month of June and October ranges from 80-110mg/L and 80-100mg/L respectively. The maximum level of hardness can be noticed in the areas of Majhitar and Rangpo which may be due to the calcium and magnesium ions discharges from the factories and industries. The high level of hardness in 32no area due to the discharge of water from wate dumped in the dumping areas for both June and October. The spatial distribution map for June is shown in Figure 5 case(i) and case (ii) below.

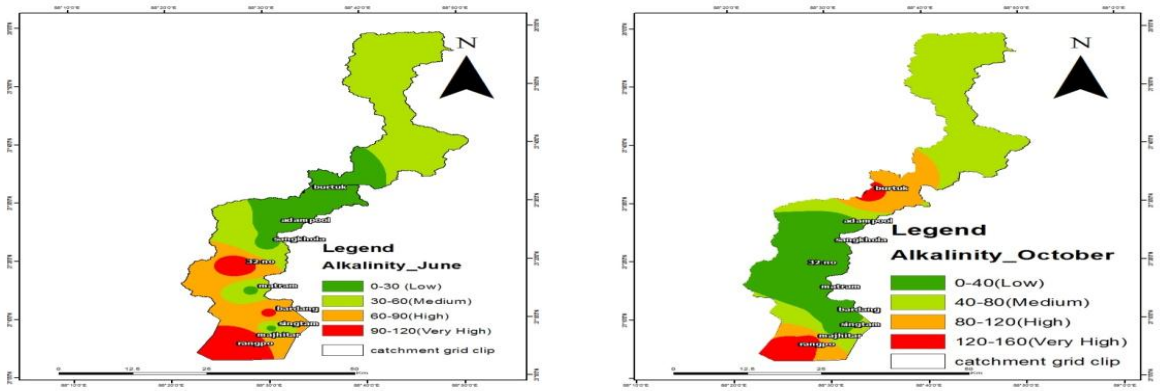


Case(i) Hardness-June-2018 Case(ii) Hardness-October-2018

Fig-5: Spatial Distribution map of Hardness

vi) Alkalinity:

The level of alkalinity ranges from 100-110mg/L and 72-130mg/L for the month of June and October respectively the alkalinity can also be noticed high in Majhitar and Rangpo area and also in 32No area in the study area in June and Rangpo during October. The source for high alkalinity may be due to the runoff of rainfall which helps in decrease in the pH level. The map for alkalinity is shown as case(i) and case (ii) below in figure 6 for the month of June and October.



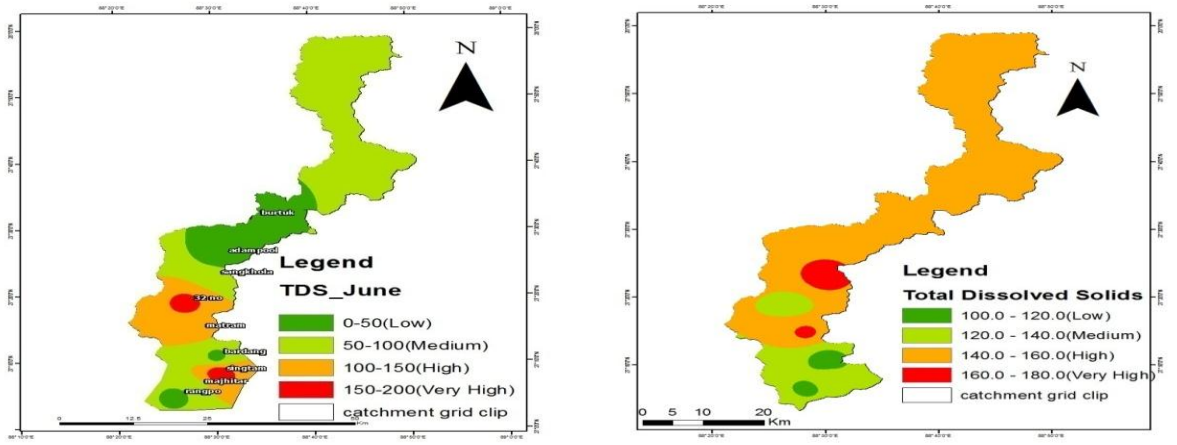
Case (i) Alkalinity-June-2018 Case(ii) Alkalinity-October-2018

Fig-6: Spatial Distribution map of Alkalinity

vii) Total Dissolved Solids:

The level of TDS ranges from 110-180mg/L and 100-170mg/L for June and October respectively. The level of TDS is greatly influenced by runoff and rainfall which leads to soil erosion thus increasing turbidity. The study area places such as Burtuk, 32NO, Adampool, Sangkhola are observed to have high TDS. The TDS was noticed highest in the area where the Conductivity, Turbidity and Chloride concentration was noticed highest .The value of TDs for the month of Octpber is quite low when

compared with the value obtained for the month of June. The spatial distribution of TDS for the month of June and October is indicated as case(ii) and case(i) in figure 7 respectively.

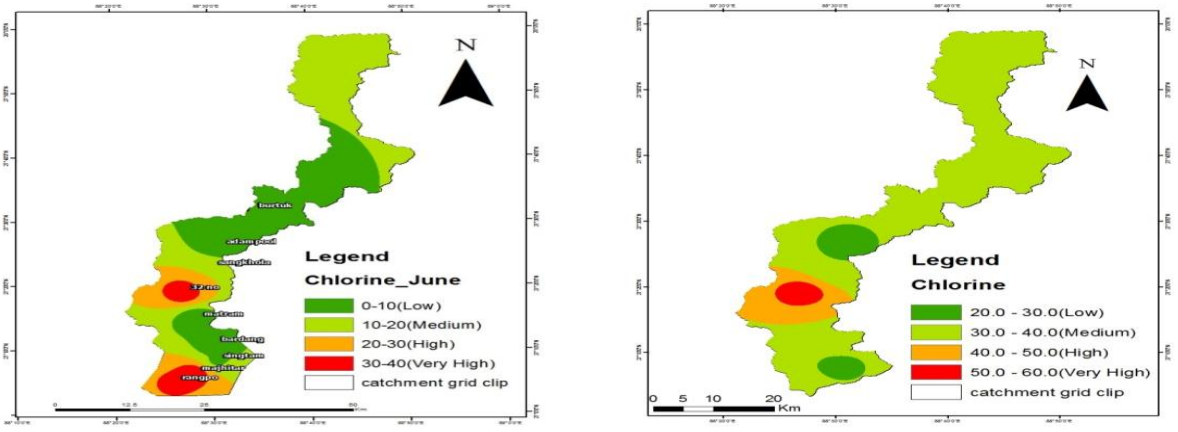


Case(i) TDS-June-2018 Case(ii) TDS-October-2018

Fig-7: Spatial Distribution map of Total Dissolved Solids

viii) Chloride:

The level of chloride ranges from 30-40mg/L and 25-60mg/L for June and October respectively. The high chloride level is basically discharge from hospitals, from the water purifying plant, and the industries and factories. The spatial distribution graph for the month of June and October is shown as Figure 8 case (i) and case (ii) below respectively. The chloride value ranged between. The value of Chloride is affected mostly from the industries such as pesticides and agriculture industries. Some concentration of chloride is also released from the pharmaceutical industries.

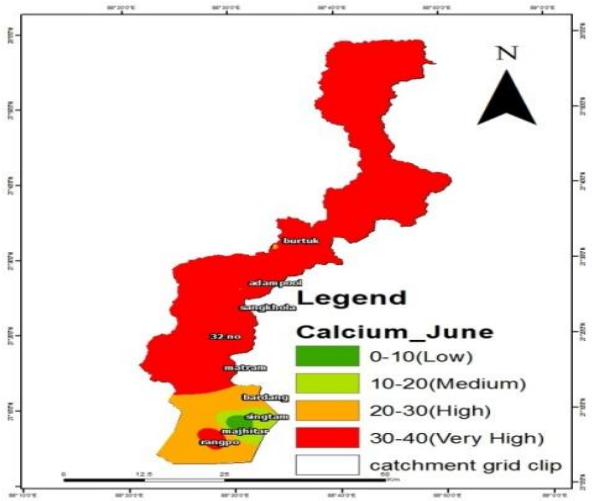


Case(i)Chloride-June-2018 Case(ii) Chloride-October-2018

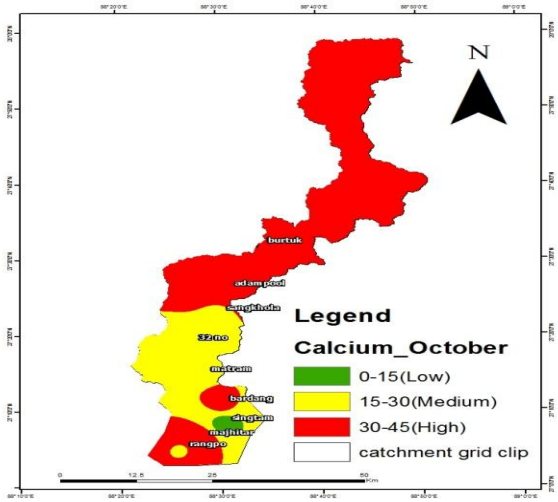
Fig-8: Spatial Distribution map of Chloride

ix) Calcium:

The level of calcium in the study area ranges from 20-36mg/L and 17-40mg/L for June and October respectively. The level of calcium in the river may be increased due to transportation of calcium constituent which is usually present in cement and most of the places in the study area is developing area where lots of construction is going on. The spatial map of Calcium is shown below in case(i) and case (ii) in figure 9. Calcium is major cause of hardness in water.



Case(i)Calcium-June-2018



Case(ii) Calcium-October-2018

Fig-9: Spatial Distribution map of Calcium

4. CONCLUSION

The paper describes about the use of GIS technology for mapping of physico-chemical parameters elated to Water Quality evaluation. In this study GIS was used as an effective tool for spatial analysis and interpretation of Water Quality. The study has explained that how GIS can be used in integration with the laboratory analysis results in mapping of Surface (River) Water Quality .Results of the study show that the lower part of East Sikki area such as Singtam, Majhitar, Rangpo and Bardang show acidic character of pH during both June and September month of 2018. The value of Turbidity is noticed high during the month of June which may be possibly due to high surface runoff and River Bank erosion when compared with the value of October. Some physico-chemical parameters such as Calcium, Chloride, Conductivity are low which indicates that they are no a major factor contributing to Water Quality Degradation.

Thus GIS Spatial maps give better visual scenario to understand the Water Quality. The results suggests that lower part of area under East Sikkim needs better treatment facilities for Water before releasing the water from the factories and industries so that it can be used for irrigation, fisheries and also for various household purposes. Some of the people even prefer these water for drinking, hence the river water requires a better treatment and Suitable management techniques for preservation of water quality of River Teesta.

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