Developing Village Level Water Quality Information System: A Case Study of Amroha Tehsil, Uttar Pradesh, India

Ravinder Singh
Dept of Geography
Panjab University, Chandigarh

Abstract- *Existence of life on earth is due to the availability of water and human'ssettlements depend on the adequate supply of water for domestic and other uses. Water is the foundation of health, hygiene, progress and prosperityin any nation. Water being the fundamental need for the human subsistence requires proper management. Therefor efficient water management system is essential to civil society for development of quality of life. As the development has expanded in the form of urbanisation, industrialization and globalisation the pressure on the limited water resources is increasing. Overexploitation, poor management, dumping of toxic materials into the streams and underground water channels is steadily degrading the physical environment out of which pollution of underground water sources is the least recognized one. Magnitude of the pollution and degradation of the ground water resources is directly dependent on the geographical environment of the area and the anthropogenic activities being carried out above it.In the light of the above discussion the present study attempts to develop an open source web based Geographical Information System (GIS) of the Village Level Water Quality Information System. For the purpose field work was carried out in the three villages () .Total of seven physico-chemical parameters like Fluoride, Iron, Nitrate, Turbidity etcwere considered in the analysis and the quality of water was indicated using and index value. Results are published online using web based online GIS with suitable graphical and tabular forms.*

Keywords- Water quality, spatial distribution, GIS

I. INTRODUCTION

Water being essential of any for any form of life on the earth is available in abundant as almost three forth of the surface of the earth is covered under the water. But less than one percent of it is fit for human consumption out of which only one hundredth parts is available in the form of drinking water. So it becomes very important to preserve the drinking water resources made available by our environment.

Development in the form of urbanization, industrialization and globalisation has been putting enormous pressure on the existing water resources and is polluting them. Water is one of the most essential natural resource for sustainability as it continuously facing huge demand due to rapid growth of population, expansion of urban areas,growth of industries and enlargement of agricultural land. Having safe drinking water is right of every human. Clean water is basic need for maintaining good health and dignity. There is always some variation is the availability and accessibility of the water due to technological level, geographical conditions, topography, time of the year, and quality of the water.Hence, the conservation, optimum utilization and management of the water resource for the betterment of the economy, social and physical health status of the people become paramount.

The definition of water quality is very much depending on the desired use of water. Therefore, different uses require different criteria of water quality as well as standard methods for reporting and comparing results of water analysis.

II. OBJECTIVES

The main objective of the present study is to generate geo-spatial database at village level of the quality of ground water resources. Secondly it will attempt to develop web based water quality information system and publish the results on the online GIS web based system. And finally to generate awareness among the people and communities regarding the quality of ground water and conservation of fresh water resources in their area.

III. METHODOLOGY

The present study focuses on the assessment and mapping of the quality of ground water in the Amroha tehsil located in the JyotibaPhuleNagar District of Uttar Pradesh. Primary field survey was conducted and samples of drinking water were collected from the hand pumps i.e. the only source of the drinking water in the study area.Samples (approximately twenty from each village) were selected randomly and water quality testing was performed on the collected samples using the kit provided by the Uttar Pradesh JAL Nigam Located at Lucknow and tables and maps were prepared using ArcGIS software and results were published on the online web GIS portal.

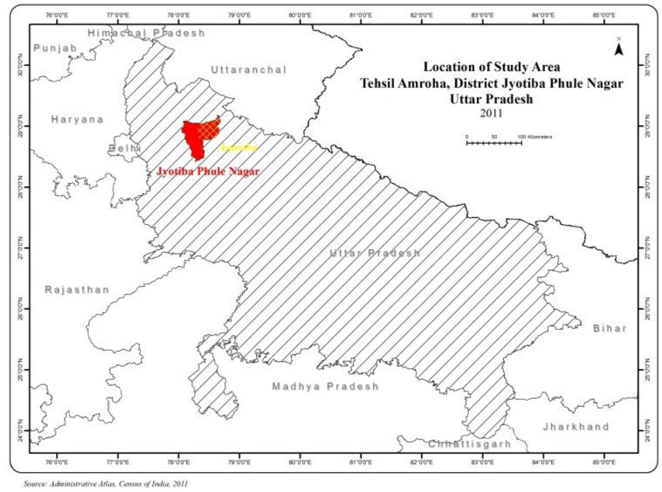
Plate: 1

Water Quality monitoring equipment is provided by UP JAL Nigam Lucknow containing chemicals and apparatus to test water quality data of 100 samples.

IV. STUDY AREA

The present work is carried out in the three villages namely Gangadaspur, DhanauraAheer and DhelaNagla of Amroha tehsil situated in the JyotibaPhule Nagar District located in the North western flank of the state of Uttar Pradesh. The population of village Gangadaspur is 2148 persons, village DhanauraAheer is 2210 and in village DhelaNagla is 680 persons (Census of India, 2011). The area is located within the humid subtropical type of climate with dry winters. Rainfall is brought by the monsoon in the summers. The soil of the region is basically alluvium brought by the Ganga River system. The area is located in the heart of the Indo-Gangetic plains, Himalayas are located in the north. The area is generally very good in agricultural production and it is part of the sugarcane, rice and wheat belt of the country.

Map: 1



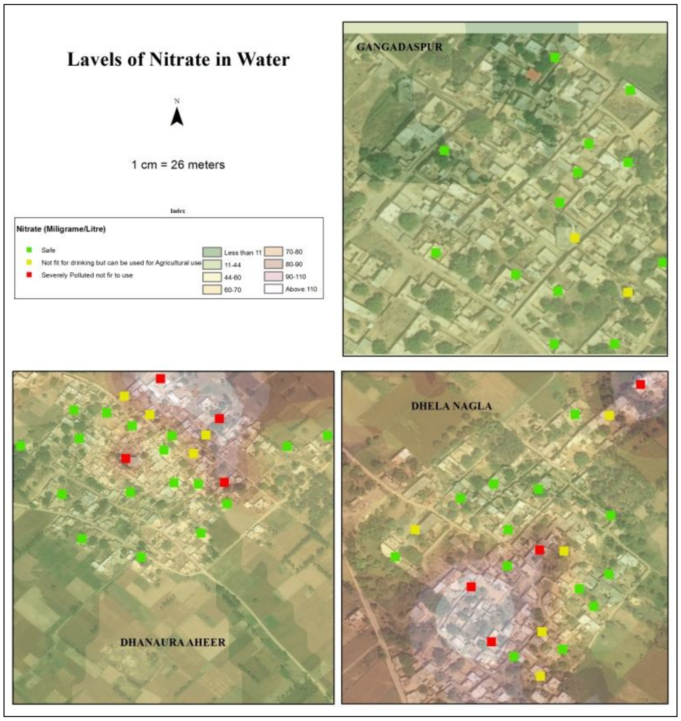
V. RESULTS AND DISCUSSION

Quality of water has always been a matter of concern for the humans. Not all sources of waters are fir for human consumption. State level authorities spend huge amount of money in order to make water available for drinking and domestic consumption. But the rising demand of fresh water due to the rapid growth of Human population along with the development and increase in the number of industries and expansion of urban areas have deteriorated the quality of water available.

The study shows that there are variations in the quality of water even at the village level. Three villages were selected as a sample and twenty samples from every village were collected. Water quality test were carried out on them and following results were obtained:

Nitrate (NO3) measured in terms of milligram perlitre of water is an indicator of quality of water. The environmental protection agency has prescribed the safe limit of nitrates in the drinking water at 10mg/L. If the limit of the nitrates as nitrogen increases above this level they are known to cause a potentially fatal blood disorder in infants called methemoglobinemia or "blue-baby" syndrome (Benton Franklin Health District, 2017)Six out of twenty samples collected from the Gangadaspur village were severely above the prescribed levels. Same was in the case of DhanauraAheer village where seven out of twenty were found to be above the limit of ten milligram per litre of water. DehlaNagla village is not exception with seven out of twenty two samples above the limit. Map2 shows the patterns of nitrate levels in the villages.

Map: 2



Source: Primary Field Survey, 2012

The levels of chloride are also and important indicator of how good is the water for human consumption. According to the environmental protection agency the advisable levels of chloride in the drinking water should be less than four parts per million to be considered it as safe for drinking (Water Quality and Health, 2017). Chlorine based disinfectants can provide protection from the water borne diseases.Village Gangadaspur had six out of the twenty samples with level of chloride more than twenty five milligrams per litres, village DhanauraAheer was found to be having eight out of twenty samples to be more than the permissible value whereas in the village DhelaNagla almost all (20 out of 22) the samples of the drinking water were found to be contaminated with the high levels of chloride in the water. Map 3 shows the spatial distribution of the Chloride levels in the study area.

Fluoride is an ionic compound which is added to the public water supply at the permissible levels of one part per million (1 ppm) (Live Science, 2017). The levels of fluoride in the natural water resources are generally below the three parts per million marks. It concentration in the ground water resource depends on its geographic location and distance from the source of pollutants such as industries. All the three villages i.e. Gangadaspur, DhanauraAheer and DhelaNagla have recorded less than 0.5 milligram of Fluoride in the sample of one litre of waterwhich is safe for human consumption.

Table 1 shows the levels of different parameters of quality of drinking water in the sampled villages.

*Table: 1***Water Quality Indicators of Sampled Locations, 2012**

Village Name	***Sample No***	***Nitrate, NO3(mg/L)***	***Chloride, Cl(mg/I)***	***Fluoride, F(mg/I)***	***Iron ,Fe(mg/ 1)***	***PH Value (6.5-8.5)***	***Turbidity (NTU)***	***Hardness, CaCo3(mg /I)***
Gangadaspur	1	10	25	0	0.2	7	10<	285
Gangadaspur	2	10	25	0	0	7	10<	240
Gangadaspur	3	10	75	0	0	8	10<	315
Gangadaspur	4	100	50	0.5	0.3	6	B/w 10-25NTU	240
Gangadaspur	5	100	50	0	0.3	7	10<	450
Gangadaspur	6	10	25	0.5	0.3	7	10<	210
Gangadaspur	7	10	50	0	0.3	6	10<	300
Gangadaspur	8	250	25	0.5	0.2	6	B/w 10-25NTU	165
Gangadaspur	9	10	25	0.5	0.3	7	10<	210
Gangadaspur	10	10	25	0.5	0.2	7	10<	375
Gangadaspur	11	10	100	0.5	0	6	10<	315
Gangadaspur	12	250	75	0	0.2	6	10<	150
Gangadaspur	13	10	25	0.5	0.2	8	10<	150
Gangadaspur	14	10	25	0.5	0.3	6	10<	300
Gangadaspur	15	10	25	0.5	0.2	6	10<	150

Gangadaspur	16	10	25	0	0.2	7	10<	330
Gangadaspur	17	100	25	0	0.3	8	10<	315
Gangadaspur	18	10	25	0.5	0	7	10<	225
Gangadaspur	19	10	50	0.5	0.3	8	10<	360
Gangadaspur	20	10	25	0	0.3	7	B/w 10-25NTU	450
Gangadaspur	21	45	75	0.5	0.3	7	B/w 10-25NTU	285
DhanauraAheer	*22*	250	50	0.5	0.2	7	10<	225
DhanauraAheer	23	250	25	0	0.3	6	B/w 10-25NTU	315
DhanauraAheer	24	10	25	0	0.3	6	10<	195
DhanauraAheer	25	10	50	0.5	0.3	6	10<	195
DhanauraAheer	26	25	25	0	0	6	10<	300
DhanauraAheer	27	10	25	0.5	0	6	10<	330
DhanauraAheer	28	10	25	0	0.2	6	10<	300
DhanauraAheer	29	10	25	0.5	0.4	6	B/w 10-25NTU	300
DhanauraAheer	30	250	50	0.5	0.3	6	10<	375
DhanauraAheer	31	100	75	0.5	0	7	10<	225
DhanauraAheer	32	10	25	0.5	0.3	7	10<	405
DhanauraAheer	33	10	25	0.5	0.2	6	10<	600
DhanauraAheer	34	10	50	0.5	0.2	7	10<	525
DhanauraAheer	35	250	25	0.5	0.2	7	10<	225
DhanauraAheer	36	100	50	0.5	0.2	7	10<	75
DhanauraAheer	37	10	50	0	0.2	7	10<	275
DhanauraAheer	38	10	50	0.5	0.2	7	10<	300
DhanauraAheer	39	10	25	0.5	0	7	10<	300
DhanauraAheer	40	10	50	0.5	0	7	10<	225
DehelaNagla	41	10	50	0	0.2	7	10<	270
DehelaNagla	42	100	75	0.5	0	6	10<	360
DehelaNagla	43	100	25	0.5	0.2	6	10<	180
DehelaNagla	44	10	25	0.5	0.3	7	10<	150
DehelaNagla	45	250	50	0.5	0.3	8	10<	375
DehelaNagla	46	250	50	0.5	0.3	6	10<	330
DehelaNagla	47	10	50	0.5	0.4	6	10<	315
DehelaNagla	48	10	125	0.5	0.2	6	10<	150
DehelaNagla	49	10	150	0	0.2	7	10<	210
DehelaNagla	50	10	150	0.5	0.3	6	10<	120
DehelaNagla	51	10	100	0.5	0.3	6	10<	150
DehelaNagla	52	10	75	0.5	0.3	6	10<	120
DehelaNagla	53	10	100	0.5	0.4	6	10<	105
DehelaNagla	54	10	100	0.5	0.2	7	10<	135
DehelaNagla	55	10	100	0.5	0.2	7	10<	120
DehelaNagla	56	10	75	0.5	0.3	7	10<	165
DehelaNagla	57	25	75	0.5	0.3	7	10<	120
DehelaNagla	58	10	100	0.5	0.2	6	B/w 10-25NTU	90
DehelaNagla	59	45	125	0	0.3	8	10<	105
DehelaNagla	60	10	75	0.5	0.2	7	10<	120

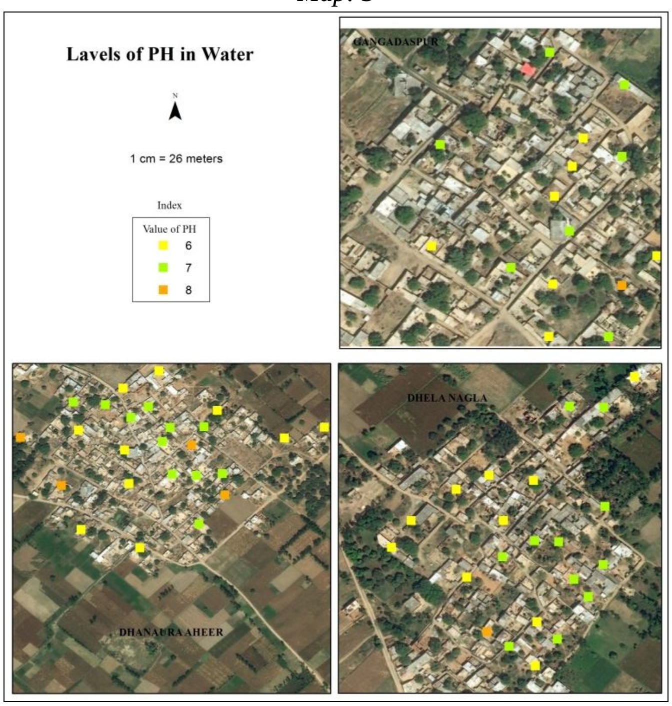
DehelaNagla	61	10	100	0.5	0.3	7	10<	135
DehelaNagla	62	10	75	0.5	0.2	6	10<	165

Source: Primary Field Survey, 2012

Level of Iron in the drinking water is a good indicator of its quality. Iron is one of the common metallic elements found in the water in the nature.For the purpose of drinking the water standard for iron is 0.3 milligrams per liter (mg/l) (Ann, T et al, 2005). In the Gangadaspur village the level of iron in the drinking was found to be 0.3 or less in all the samples. In village DhanauraAheeronly one sample was found where the level of iron was above the required level. In Dehela Nagle village only two out of twenty two samples collected were found to be above the permissible levels.

PH values are used as an indicator to assess the quality of water raning from the scale of 1 to 14 where 7 is in the middle which is treated as neutral level of pH for drinking purpose (wellcare, 2017). The rage of pH from 6.5 to 8.5 is roughly taken is safe drinking water. The study area showed the variations from 6 to 8 which are safe for human as well as agricultural land use. Map 3 shows the distribution of PH value in the sampled villages.

Map: 3



Source: Primary Field Survey, 2012

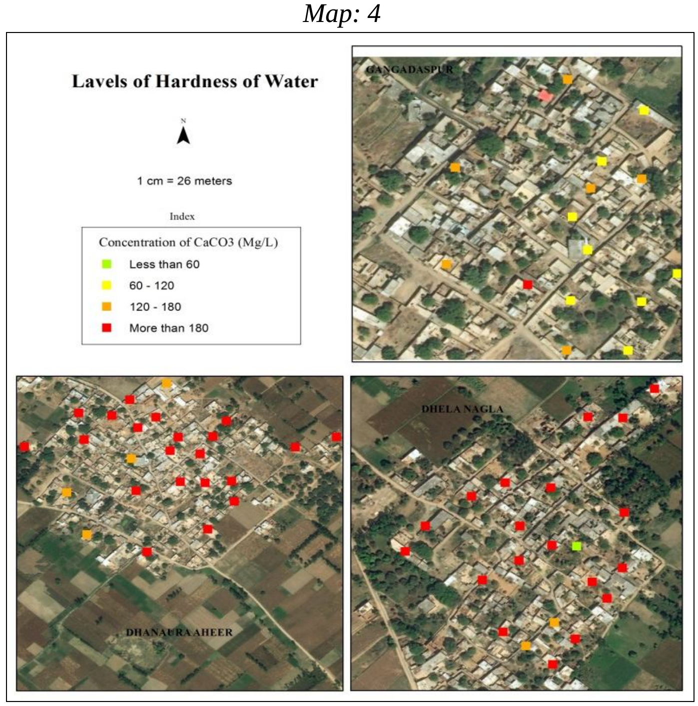
Turbidity is the measure to access the opaqueness and transparency of the water due to the presence of suspended particulate matter.As the proportion of suspended matter increased the murkier the water becomes and more becomes the turbidity of the water (Lenntech, 2017). Turbidity is considered as one of the good parameters of assessing quality of water. Sampled villages were observed to have less than ten NTU of turbidity in majority of its samples whereas according to the World Health Organisation the maximum turbidity of water to be considered fit for drinking purpose should be less than one NTU.

Hardness of water is categorised into four categories i.e. Soft water, moderately hard water, hard water and vary hard water. Table 2 shows the quantities of CaCO3 in the water and their respective categories. Map 4 shows the patterns of hardness of water in the study area. Majority of the areas in the sampled villages were found to be under the very hard category of the water having levels of CaCO3 of above 180 mg/L. Only village Gangadaspur had few areas in the hard water category having CaCO3 levels between 120 to 180 mg/L. Single sample located in village DhelaNagla was observed to be under 60 mg/L.

Table: 2

Concentration as CaCO3	Indication
0 to 60 mg/L	Soft water
60 to 120 mg/L	Moderately hard water
120 to 180 mg/L	Hard water
>180 mg/L	Very hard water

Map: 4



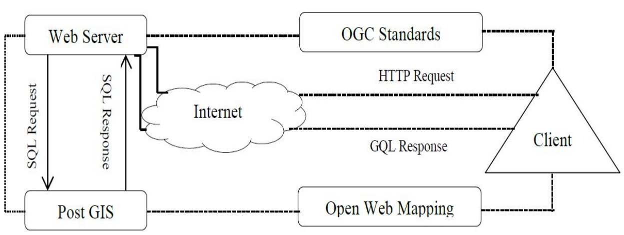
Source: Primary Field Survey, 2012

Developing web application for information dissemination:For the present study a web based GIS application was developed in order to provide information to the local people who can access the information through any web browser. The application was developed in four stages i.e. System configuration, Basic system design, Database and development.

System Configuration:A web based server i.e. map server (Geoserver) was used to develop the application. It is a Java-based software server that allows users to view and edit geospatial data. Using open standards set forth by the Open Geospatial Consortium (OGC), Geoserver allows for great flexibility in map creation and data sharing.

Basic system design: Web browser based application allows greater flexibility to the user by the means of filters and query options. A user can search for a specific location, time, area, element or perimeter of the quality of water in this application. A user inputs his basic criteria for selection of area and parameters and the requests from user will be sent to clients by way of HTML forms.

Figure: 1



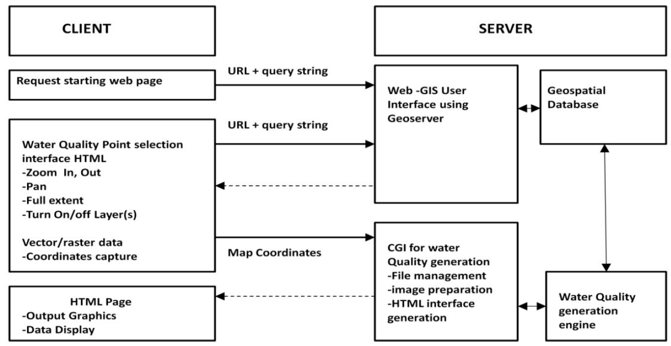
Basic Web GIS Setup

The form is passed to the web server. A gateway at the web server passes the request to a GIS server. The basic series of steps is firstlycreating the form and then pass the arguments to a script (CGI). After receiving requests the server will then: i) Process the spatial analysis or Mapping request,ii) Make the necessary map and translate it to a BMP file,iii) Translate the BMP file to JPEG or GIF file, iv) Serve the image and data listing by HTML.

Database:The 'back-end' of water quality system is a PostgreSQL (often referred to as 'Postgres') database coupled with the additional PostGIS package; both of the products are OGC compliant and open source.Postgres is an enterprise class relational database system that has been in use for over fifteen years(www.postgresql.org).PostGIS'spatially enables' the Postgres database by adding support for geographic objects, allowing it to understand coordinate systems, projections, transformations, etc (PostGIS, 2017).

Developing an application: A GIS Server (Geoserver) allows customers to compile, manage and disseminate geographic information. Information is compiled into and stored within object relational spatial databases using a geodatabase information model that supports the key types needed by applications including features, relationships, networks, imagery, terrains, maps and layers. Information is managed using both short and long transaction models that include support for versioning, archiving and replication. The GIS Server allows administrators to selectively publish this information to clients using stateless web services based on OGC interfaces. These geospatial web services support visualization, analysis, data access and replication.

Figure: 2



System Flow Diagram

The water quality data has "Water Quality" information consists of projected latitude and longitude values that relates to its sampling locations. Within the geodatabase is a pre-existing Water Quality Sampling point dataset; this dataset already contains spatial and geometric information. Once the data has been uploaded to the geodatabase and has spatial attributes, it needs to be "published" within Geoserver. The publishing of data allows Geoserver the ability to interpret the data and render it at a later stage within the web viewer or local machine. The information required by Geoserver includes the bounding box of the data (the extent), the projection of the data, and a default style which is to be applied. Publishing is commonly done via the web administrator tool within Geo-server. This, however, is impractical in our application as it would then require the user to access the web admin tool, reference the data in the geodatabase and define parameters manually; which is both time consuming and too complex for non-experienced users. To avoid this, we implemented a command procedure on the server side which forces Geo-server to publish the data automatically without going through Geo-server's web admin tool. Coding wise, this is simplified as both the projection and bounding box are constant for all the model outputs in this project and a default style can be chosen depending on whether the data is point or polygon in format. Once this process is completed the data is ready to be visualized and queried in the web viewer (For our project in our local machine).

Once the web page with the spatial visualization tool has opened, a request is sent from the tool to Geo-server for the data to render in the map viewer. Data can be transmitted from server to user as a vector as an image via a Web Mapping Service (WMS). The amount of information required to be transmitted from server to the user and the level of possible interaction with the data is dependent on the format requested. The reason why vector requests require more information to render is that spatial data for each vertex is required to represent the polygon. As the visualization tool for this project was primarily designed for viewing and basic querying, a WMS approach for rendering data in the web viewer was selected. The WMSrequest renders a georeferenced image of the data in the web viewer which can then be interacted with.

Once an external model is completed, and data is ready to be visualized. When the user clicks on the feature, an SQL code is generated and the process of publishing begins. Upon completion of the publishing task the software launches the visualization web page and opens the viewing tool whilst automatically switching to the "Display and interact" task to render the data. This complex network of functions is hidden from the user and the entire process occurs within a short timeframe. From a single click the user has gone from having tabular data into having a spatial representation of their data that they can now interact with.

VI. CONCLUSION

The basic aim of the present study was to develop an online web based GIS system that enable the users to interact with the data collected and compiled by the researcher and made available to them using the world wide web. The initiative taken to adopt a Geographical Information System based approach to develop spatial information system and knowledge based on the water quality data collected from the three villages of the Uttar Pradesh state located in the J. P. Nagar district have been accomplished. The database of the Quality of water of the three villages namely Gangadaspur, DhanauraAheer and DhelaNagla was created and published online using a geo-server. This approach can be replicated at a larger scale in order to provide information and to develop better understand of the local residents. This approach is not only economically viable but also is easy to replicate and verifiable at any level.

The Government authorities should concentrate on water quality monitoring and surveillance strategies for rural villages. The outputs of water quality mapping exercise provide a synoptic view and would form a powerful tool for monitoring water quality across the region. The GIS database also helps in decision-making process by identifying the most sensitive zones that need immediate attention. The planning process can also foresee the quality fluctuations and decide upon the priority, schedule, corrective measures and protection aspects with finer details.

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