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Development of Integrated Geographic Database for Water Quality Analysis

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ABSTRACT

Ground water is source for water supply in many parts of the world catering to the requirements of one third of global population. In fact, the declining status of global fresh water resources both in terms of quantity and quality may prove to be the dominant issue on the environment and development agenda of the coming century. To provide safe drinking water, it is required to plan and design a project with economy and safety. Planning is all about dealing with various kinds of data, to analyze them and to make a suitable decision. Present work is generation of GIS based database for water quality parameters of Allahabad city. At any time, if one wants to update this data, it could be done by directly overwriting the old data. The attribute data table of a particular feature is then linked to its corresponding location in the shapefiles. Thus, the water quality parameters are now linked to each location of hand pump as well as to the tube well sampling locations as attributes as well as for water treatment plant and clear water reservoir.

Keywords: Water quality, Spatial data, Non spatial data

I. INTRODUCTION

It is common knowledge that fresh water, a finite and fragile resource is increasingly becoming scarce day-by-day. One third of the world's population is already living in countries with moderate to high water stress, where water consumption is more than 10 percent of the renewable fresh water supply. Nearly 20 percent of the world's population lack access to safe drinking water and around 50 percent adequate sanitation. The problems are most acute in Africa and West Asia; besides it is a major constraint in the overall socio-economic growth in many countries including China, India and Indonesia. Similarly, degradation of water quality to abnormal levels over a period of time is a challenging problem. Even in a developed country like United States, it is reported that in 1994, 40 million people consumed water with high nitrate content (Daniel, 2001). Ground water is source for water supply in many parts of the world catering to the requirements of one third of global population. Over extraction of ground water has also affected its quality leading to saline ingress in coastal areas as in case of Oman, Bahrain, and India. It is reported that biological contamination in the form of the fecal coliform count in Asia's rivers is 50 times higher than the WHO guidelines making the local population vulnerable to high risk level. In fact, the declining status of global fresh water resources both in terms of quantity and quality may prove to be the dominant issue on the environment and development agenda of the coming century.

1.1 Integrated Database and Water Quality

To provide safe drinking water, it is required to plan and design a project with economy and safety. Planning is all about dealing with various kinds of data, to analyze them and to make a suitable decision. Hence, it can be easily understood that a suitable plan depends over the ability to analyze the data effectively

and bring out the hidden message in it. Efforts are having been made continuously to provide effective tools to sort out a proper and economical decision for any proposal or project. Since the invention of computers, considerable work has been done in this direction. Today there are many powerful computer related tools as different software packages and CAD/CAM technologies. Technological revolution has provided a new dimension to the information systems, which led to the emergence of new specialized branch of knowledge and computer networks. There has been a rapid development in the field of geographic information science. Geographic Information System (GIS) provides information on all geographical variables and has a vital role to play in the water related studies. A GIS is a computer based system which is designed to assist decision makers. Typically, such a system will include spatial data relevant to the decision, analytic tools to process the data in ways meaningful for decision makers, and output or display functions (Internet 1).

1.2 Objective of the Present Work

Now-a-days, GIS has become an indispensable tool for monitoring of water quality in an efficient way. In the present work the water quality parameters of three different seasons, namely, winter, summer and monsoon seasons have been used. In particular, the main objective of the present work is generation of GIS based database for water quality parameters of Allahabad city.

II. STUDY AREA

The present study has been carried for Allahabad city which is covered between 25°31'04"N to 25°22'44"N latitudes and 81°55'00"E to 81°54'04"E longitudes. The boundaries of the city are selected from the distribution map available from Jal Sansthan, Allahabad. As water quality data available from National Environmental Engineering and Research Institute (NEERI), Nagpur includes the water quality data of Phaphamau so this sampling area is also considered for present study. Total Area of city is 85.00 sq. km.; population of the city is approximately 10, 49,579 people (as per 2001 census) and altitude of city is 98 meters above sea level. The maximum temperature reaches the mark of 45.6°C and minimum temperature 1.1°C. The annual average rainfall is 1935.5 mm. The study area along with locations of water sampling is shown in Figure1.

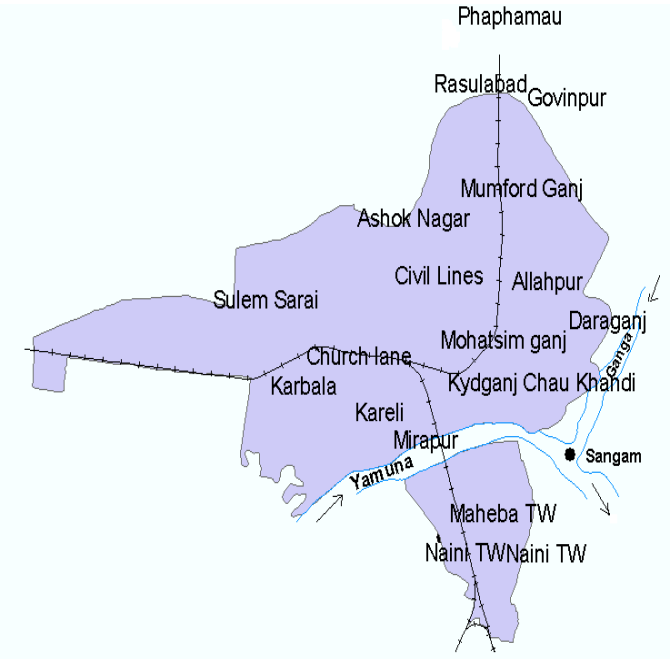

Figure 1. Study Area

2.1 Collection of Data

In the present study, topographic maps, covering Allahabad city, published by Survey of India and city map prepared by Nagar Mahapalika Allahabad have been used. These maps show various features of the city. The scales of the 63G topographical map is 1:250,000 and the scale of 63G/15 is 1:50,000. The utility services map for Allahabad town with scale 1:20,000 has been provided by Jal Sansthan, Allahabad. Water quality data for present study are taken. Water quality data are taken from Jal Sansthan for all three seasons and for tube wells, hand pumps, clear water reservoir and water treatment plant.

2.2 Geo referencing of the Maps

The various maps collected were scanned at 300 dpi. The ArcGIS 8.3 software has been used for present study. Registering a map is first step towards generating a database. After registration of a map, it fits into its real world coordinate and gives us real distances and relative locations of various places. In this process, maximum numbers of control points which are well distributed in maps are identified from the paper map and have been used to the scanned map in the ArcMap to register it. Polyconic projection system with India Everest as datum has been used because the same system has been adopted by Survey of India.

2.3 Spatial Database Creation

On-screen digitization process is used for the creation of spatial database. Firstly, shapefiles have been defined. After defining the various shapefiles, type of geometry is defined for a feature class. The geometry types are Point, Line, Polyline and Polygon. All these work are carried out in arc Catalog. In the process of vectorization, an ID number is assigned for joining or relating the attribute table with the corresponding spatial feature present on the map. The various features digitized include overhead tanks, tube wells, hand pumps, railway line, city boundary and rivers, *etc.* Figure 2 and Figure 3 showing digitized features.

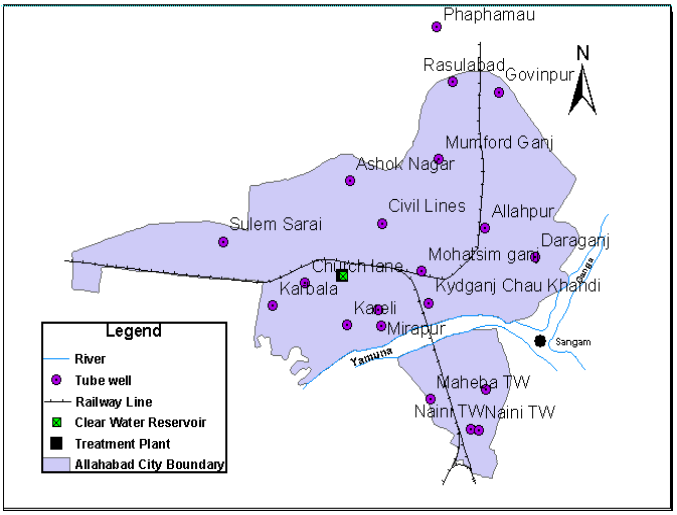

Figure 2. Locations map for tube wells and clear water reservoir

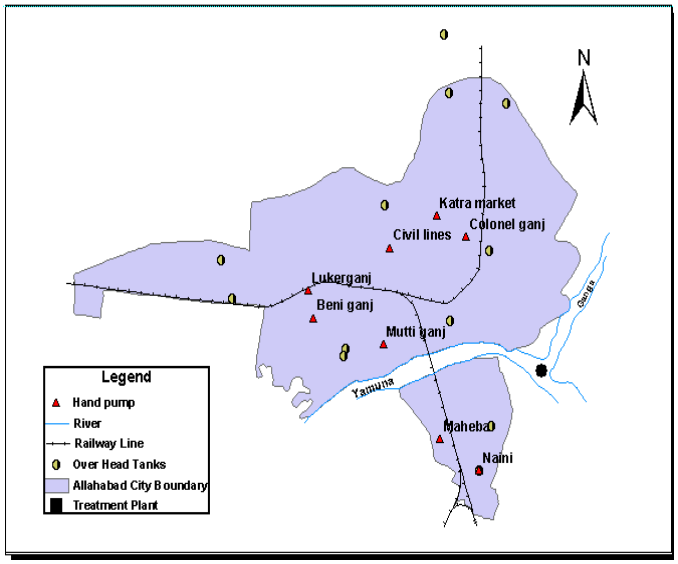

Figure 3. Hand pumps and overhead tanks locations

2.4 Non-spatial Database Creation

The water quality data for Allahabad city was available for tube wells, hand pumps, water treatment plant and clear water reservoir for winter, summer and monsoon seasons from NEERI, Nagpur. Using this data, various attribute tables in dBase have been generated. Table 1 shows water quality parameter at hand pumps for monsoon season. Subsequent tables are given below showing quality parameters for all study locations and for different season.

Table 1. Water quality parameter at hand pumps in monsoon season

Sampling_p	ID	S_No	Temp_C	pH	Turb_NTU	Cond_s_cm_	TDS_mg_l_
katra market	0	1	27	7.12	0.6	1449	1086
civil lines	0	2	27	7.13	0.4	1440	1244
colonel ganj	0	3	27	7.36	0.4	1285	1102
lukerganj	0	4	26.5	7.2	0.35	1608	1340
mutti ganj	0	5	26.5	6.81	20	3360	3298
beni ganj	0	6	27	7.18	2	1117	1012
naini	0	7	27	7.48	4.5	921	630
maheba	0	8	27	7.93	5.5	798	530

T_Alk_mg_l	T_Hard_mg_	Ca_mg_l_	Mg_mg_l_	Cl_mg_l_	SO4_mg_l_	NO3_mg_l_	PO4_mg_l_
410	560	83	86	130	74	0.78	0.12
410	540	125	55	139	7	0.9	0.09
400	412	60	63	69	29	1.14	0.05
450	532	126	52	116	19	0.81	0.2
670	632	113	84	501	18	0.34	0.06
340	424	107	37	85	19	0.83	0.08
430	332	88	27	47	27	0.6	0.06
330	284	76	22	24	26	0.4	0.06

F_mg_l_	Na_mg_l_	K_mg_l_	Phenol_mg_	Fe_mg_l_	Mn_mg_l_	Cu_mg_l_	Cd_mg_l_	Cr_mg_l_
0.01	38	3	0	0	0	0	0	0
0.09	57	4	0	0	0	0	0	0
0.01	95	4	0	0	0	0	0	0
0.01	76	2	0	0	0.35	0	0	0
0.04	104	3	0	0	0.32	0	0	0
0.39	28	4	0	0	0	0	0	0
0.4	55	4	0	0	0	0	0	0
0.04	30	3	0	0	0	0	0	0

Pb_mg_l_	Zn_mg_l_	As_mg_l_	TC	FC
0	0.98	0	10	0
0	0.19	0	16	2
0	1.53	0	0	0
0	3.41	0	10	6
0	0.33	0	18	0
0	0.97	0	0	0
0	0.4	0	0	0
0	2	0	0	0

Table 2. Water quality parameter at tube wells in monsoon

Sampling_p	S_No	Temp_C	pH	Turb_NTU_	Cond_s_cm_	TDS_mg_l_	T_Alk_mg_l
sulem sarai	1	26	7.2	0.3	981	592	298
civil lines	2	26	8	0.6	531	262	230
ashok nagar	3	26	7.9	0.2	534	266	220
mumford ganj	4	26.5	8.1	1	528	278	310
rasulabad	5	27	7.8	0.6	700	448	340
phaphamau	6	26	7.7	0.2	758	242	324
govindpur	7	26.5	7.7	0.3	528	402	324
church lane	8	26.5	7.6	0.3	688	448	310
allahpur	9	26	7.3	0.3	668	808	360
daraganj	10	26.5	7.4	0.2	988	868	318
kydganj chukhandi	11	26.5	7	3	1370	354	280
kareli	12	26	7.4	0.3	694	318	282
mohatsim ganj	13	26.5	7.8	0.4	781	494	312
mutthi ganj	14	26.5	7.8	2.5	810	328	270
mirapur	15	26.5	7.6	0.2	784	810	330
karbala	16	26.5	7.3	5.5	1214	642	480
naini	17	26	7.5	0.5	1156	444	332
naini	18	27	7.4	0.3	731	380	320
maheba	19	26.5	7.2	0.3	787	466	310
avantika colony	20	27	7.4	0.7	793	548	288

T_Hard_mg_	Ca_mg_l_	Mg_mg_l_	Cl_mg_l_	SO4_mg_l_	NO3_mg_l_	PO4_mg_l_	F_mg_l_
292	64	32	43	44	0.6	0.1	0.19
172	34	21	14	24	0.2	0.2	0.4
184	55	12	18	27	0.7	0.2	0.5
188	50	16	9	27	0.2	0.2	0.14
200	39	16	21	34	0.2	0.2	0.17
220	36	19	4	16	0.5	0.2	0.1
232	22	43	26	37	0.3	0.2	0.18
224	59	17	54	48	0.6	0.2	0.25
308	45	29	135	140	0.3	0.1	0.15
392	24	81	175	136	0.6	0.2	0.18
276	35	46	35	18	0.3	0	0.5
248	19	24	26	27	0.4	0.4	0.1
340	40	58	95	142	0.6	0.2	0.2
248	42	35	7	21	0.3	0.1	0.1
408	34	79	82	68	0.8	0.4	0.1
336	10	76	68	76	0.5	0.2	0.1
320	88	24	52	62	0.5	0.1	0.2
280	90	14	32	23	0.4	0.2	0.15
284	88	16	34	14	0.4	0.2	0.8
296	59	36	38	46	0.1	0.1	0.3

Na_mg_l_	K_mg_l_	Phenol_mg_	Fe_mg_l_	Mn_mg_l_	Cu_mg_l_	Cd_mg_l_	Cr_mg_l_
48	5	0	0	0	0	0	0
45	4	0	0	0	0	0	0
28	3	0	0	0	0	0	0
46	4	0	0	0	0	0	0
42	4	0	0	0	0	0	0
26	3	0	0	0	0	0	0
54	5	0	0	0	0	0	0
55	4	0	0	0	0	0	0
55	5	0	0	0	0	0	0
81	5	0	0	0	0	0	0
58	4	0	0	0	0	0	0
48	5	0	0	0	0	0	0
89	4	0	0	0	0	0	0
20	2	0	0	0	0	0	0
55	5	0	0	0	0	0	0
43	4	0	0	0	0	0	0
25	2	0	0	0	0	0	0
34	3	0	0	0	0	0	0
30	3	0	0	0	0	0	0
42	4	0	0	0	0	0	0

Pb_mg_l_	Zn_mg_l_	As_mg_l_	TC	FC
0	0	0	0	0
0	0	0	0	0
0	0.02	0	0	0
0	0.14	0	0	0
0	0.09	0	0	0
0	0.42	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0.03	0	0	0
0	0.01	0	0	0
0	0	0	0	0
0	0.01	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

III. RESULTS

As mentioned above, the attribute data feeding could be carried out simultaneously with the digitization or it could be done at a later stage after digitizing all the features in the map(s). At any time, if one wants to update this data, it could be done by directly overwriting the old data. The attribute data table of a particular feature is then linked to its corresponding location in the shapefiles. Thus, the water quality parameters are now linked to each location of hand pump as well as to the tube well sampling locations as attributes as well as for water treatment plant and clear water reservoir. In this way, the integrated geographic database is prepared for Allahabad city for further analysis of water quality. In Figure 4 and Figure 5, the attributes for water quality parameters are shown for Mutthiganj and Ashoknagar area.

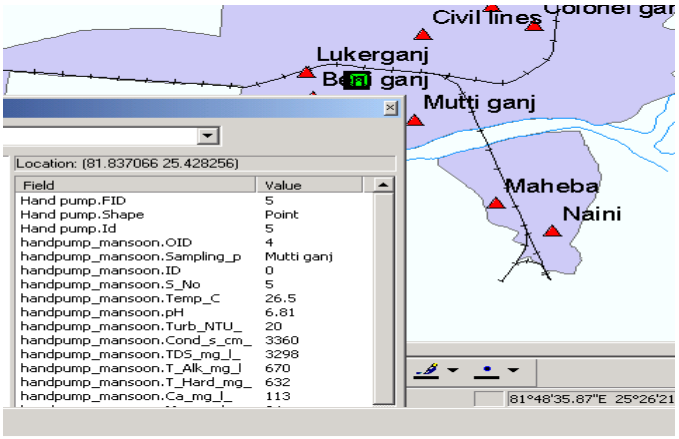

Figure 4. Quality parameter values of hand pumps of Mutthiganj

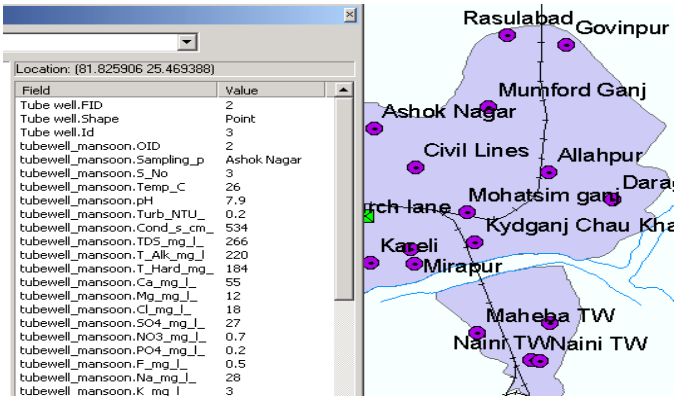

Figure 5. Quality parameter values of tube well of Ashok nagar

IV. CONCLUSIONS

In the present work, an integrated geographic database has been created using GIS consisting of water quality parameters of Allahabad city. The GIS based evaluation have given the spatial, graphical and statistical representation of groundwater and surface water parameters for assessing the quality of water for drinking purpose in Allahabad city.

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