RESEARCH ARTICLE OPEN ACCESS

GIS BASED WATER QUALITY ANALYSIS AT HAND PUMP LOCATIONS FOR ALLAHABAD CITY

Dr. Anuj Kumar Purwar
Assistant Professor
School of Engineering and Technology
IGNOU, New Delhi

Abstract:

It is common knowledge that fresh water, a finite and fragile resource is increasingly becoming scarce day-by-day. According to a report of Global Environment Outlook, the global fresh water consumption has raised six fold between 1900 and 1995 even more than twice the rate of population growth. 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. The present study has been carried for Allahabad city. 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 has given the spatial, graphical and statistical representation. Based upon the analysis carried out, it may be concluded that almost all the hand pumps require treatment of water for bacteriological contamination to make it safe for drinking or else the consumption of this water may be stopped to reduce the outbreak of health hazards.

Keywords — **Water Quality, GIS, Hand pumps, Seasons.**

1.0 INTRODUCTION

It is common knowledge that fresh water, a finite and fragile resource is increasingly becoming scarce day-by-day. According to a report of Global Environment Outlook, the global fresh water consumption has raised six fold between 1900 and 1995 even more than twice the rate of population growth. 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% of the renewable fresh water supply. Nearly 20% of the world's population lack access to safe drinking water and around 50% 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. There are many natural constraints to access to fresh water like uneven distribution, temporal and spatial variation in the climatic conditions and variations in geology and topography including

soil cover. Against this backdrop of a dismal scenario, it is encouraging to note that citizens of Jordan and Israel, two of the most water scarce countries in the world have access to adequate supplies of safe water largely due to effective and sound water management strategy warranting large scale propagation and emulation (Biswas, 2003).
India is the oldest civilization in the world with a population of one billion people. It has an area of 329 million hectares and occupies about 2% of the world's area but has 15% of its population. The country has a variety of weather conditions. The summer temperatures rise to as high as $50^{o}C$ in many parts of the country and at the same time the Himalayan range has ice capped mountains. These mountains serve a source of water for most of the northern states of India. Monsoon season is from June to October and showers India with plenty of water. It is estimated that annual rainfall in India is 400 million hectare meter. However hardly 20% of this is utilized, rest of it reaches the sea or evaporates. Although there is plenty of a water supply, India has perpetual drought conditions. Summer season spans for four months (typically from March to June) when most water bodies including dams dry out. In India, in spite of substantial emphasis on water supply sector, only about 82% of the urban household covering 85% of urban population had access to safe drinking water as of 1991. Due to improper planning of water conservation, today India is ranked 122 out of 130 nations for its water quality and 132 out of 180 nations for its water availability (Nawlakhe, 1995).

1.1 GIS and Water Quality Mapping

Urbanization has encouraged the migration of people from villages to the urban areas. This has given rise to a number of environmental problems such as water supply, wastewater generation and its collection, treatment and disposal in urban areas. In most cases wastewater is let out untreated and it either percolates into the ground and in turn contaminates the groundwater or is discharged into the natural drainage system causing pollution in downstream areas. 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.

2.0 METHODOLOGY

The methodology adopted for the preparation of database for water quality parameters of Allahabad city and for the development of the water quality index maps for all the selected models under GIS environment has been outlined with the help of flow chart, as shown in Figure 1.

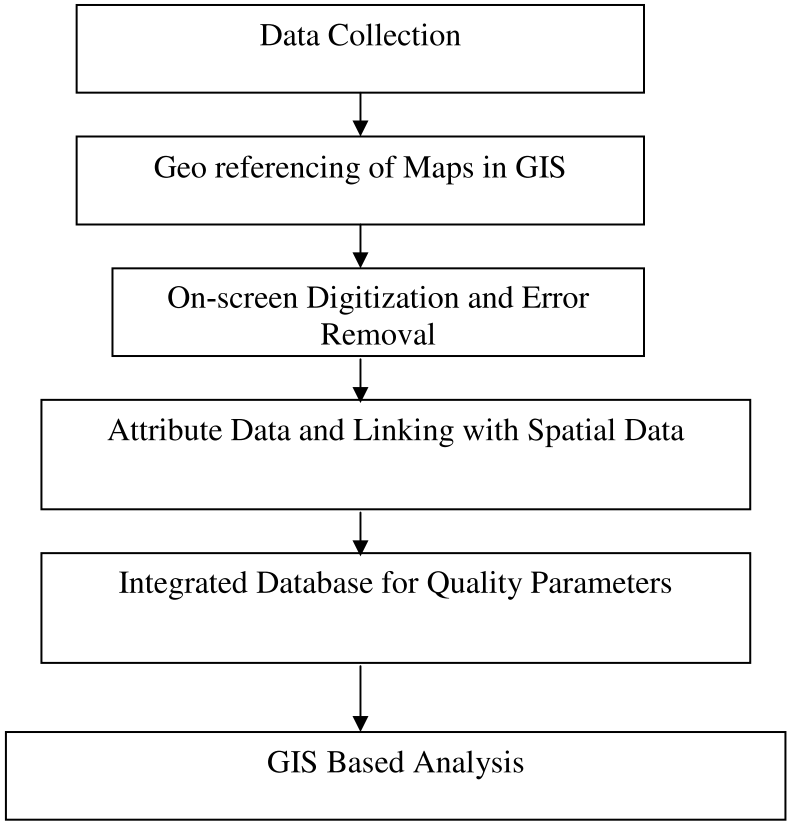

Figure 1: Flow chart for methodology adopted

2.1 Study Area

The present study has been carried for Allahabad city which is covered between 25^{o}31’04”N to 25^{o}22’44”N latitudes and 81^{o}55’00”E to 81^{o}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^{o}C and minimum temperature 1.1^{o}C. The annual average rainfall is 1935.5 mm. The study area along with locations of water sampling is shown in Figure 2.

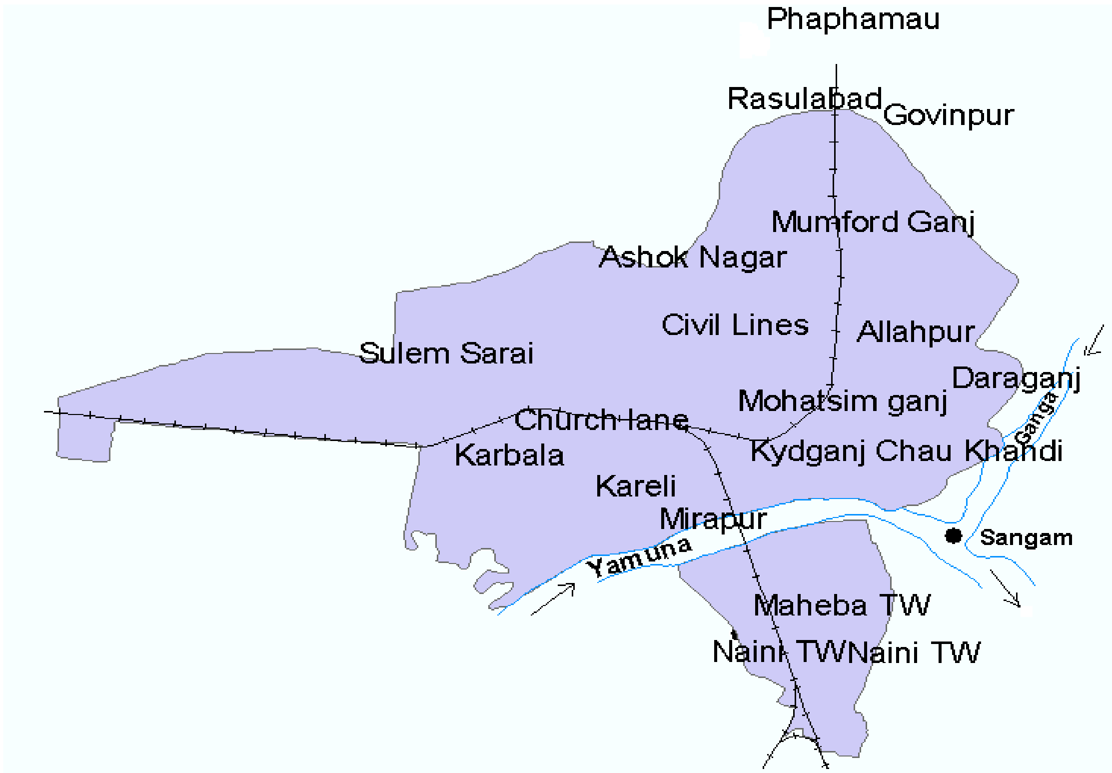

Figure 2: Study area

2.2 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.

2.3 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.

2.4 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, hand pumps, railway line, city boundary and rivers. Figure 3 showing digitized features.

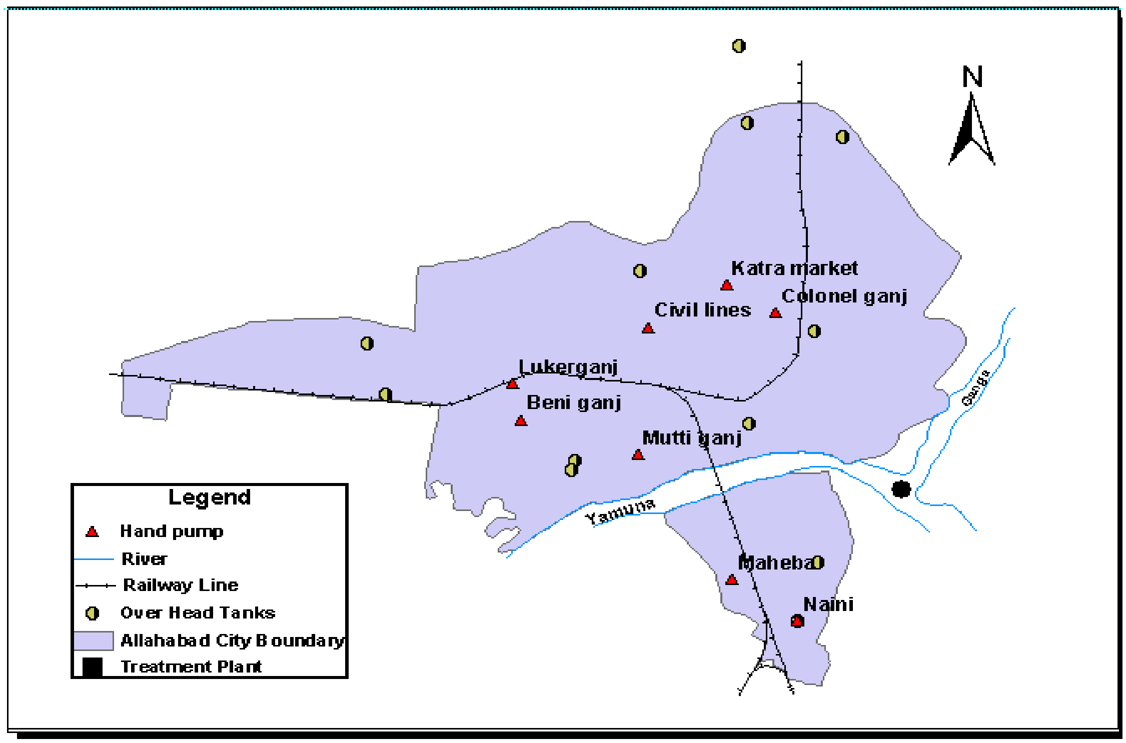

Figure 3: Hand pumps and overhead tanks locations

3.0 RESULTS AND DISCUSSIONS

After the creation of integrated geographic database, suitability of water quality parameters has been discussed. The bar charts have been made to understand the quality of water in an easy way for a specific area and to find where a parameter is exceeded from the permissible limit. Bar charts have been prepared separately for each season so as to easily monitor the water quality and study the effect of a particular season on the quality on water. Figure 4 shows the bar chart for turbidity at all the locations of hand pumps. From the above Figure 4, it is observed that Mutthiganj and Maheba are above the permissible limit of 5 NTU. On evaluation of water quality for total dissolved solids from Figure 5 above, it is observed that total dissolved solids in all areas are above the permissible limit of 500mg/l. The total dissolved solids at Mutthiganj are observed to be 3298 mg/l, which is an exceptionally high value.

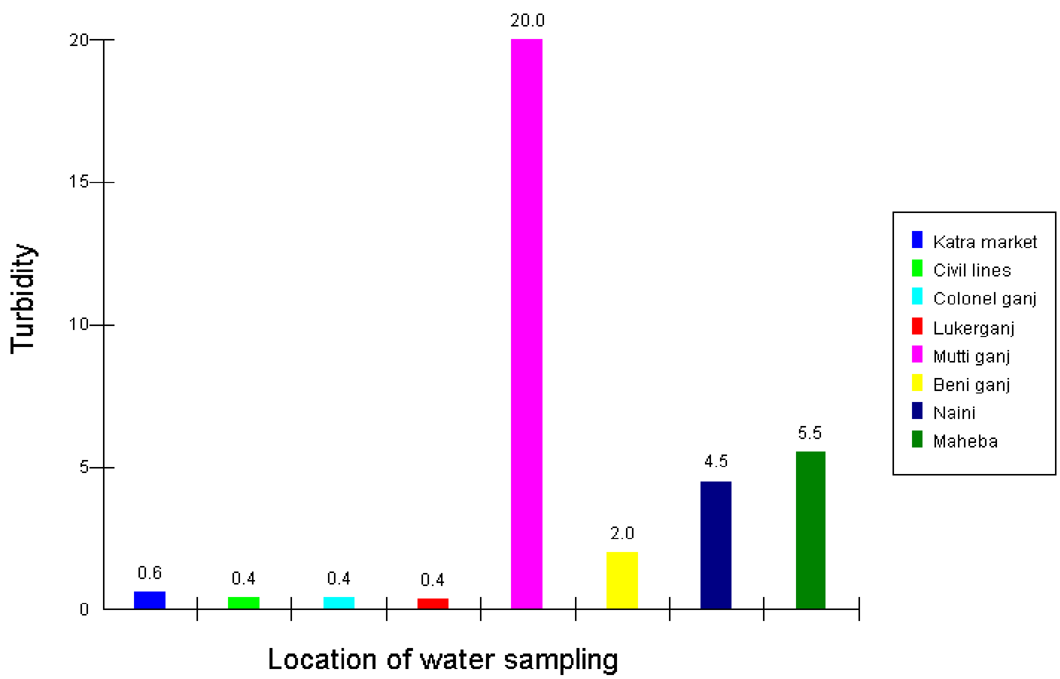

Figure 4: Turbidity at hand pumps in monsoon season

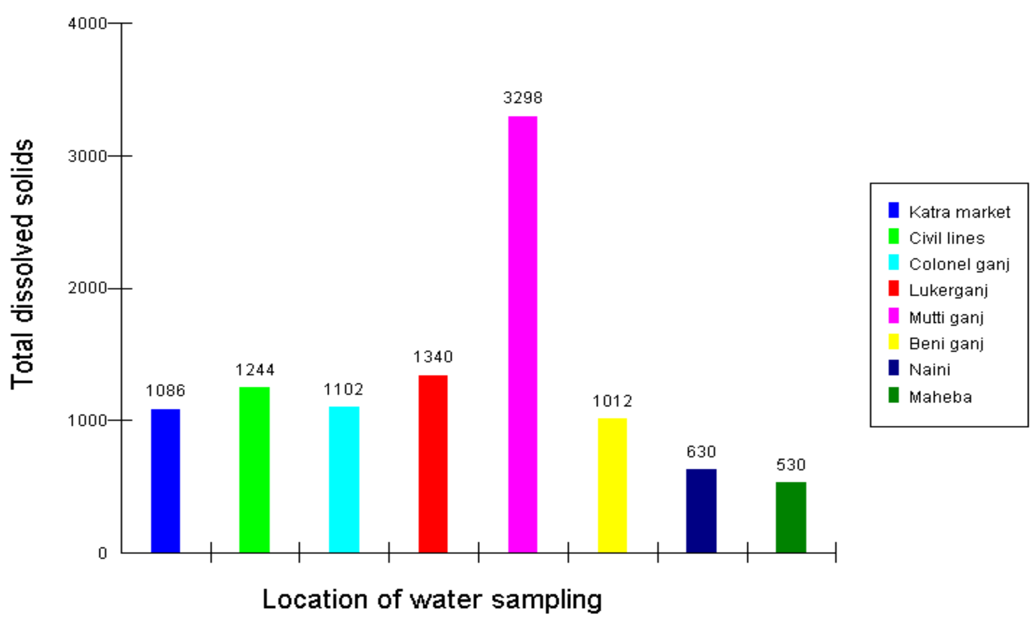

Figure 5: Total dissolved solids at hand pumps in monsoon season

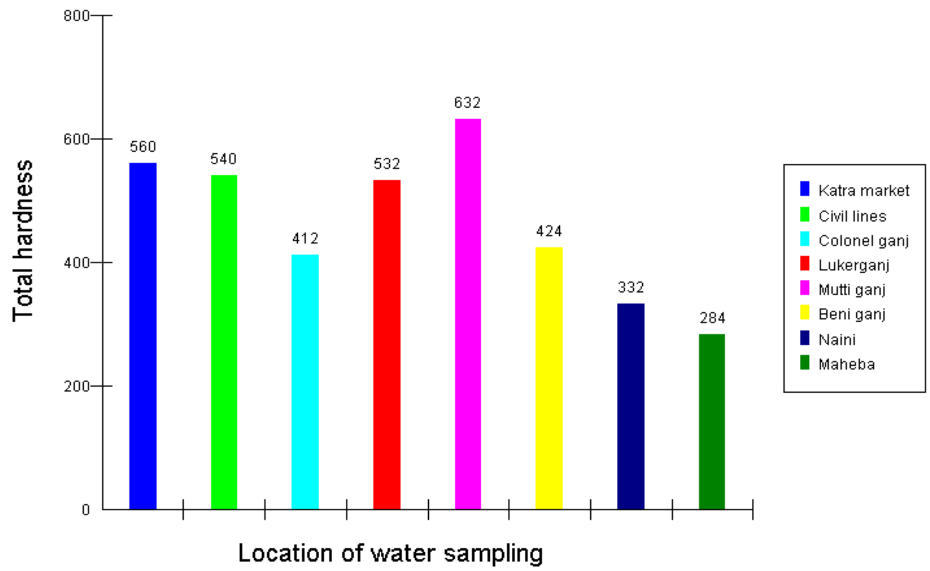

Figure 6: Total Hardness at hand pumps in monsoon season

Total hardness of hand pumps of areas like Katra market, Civil lines, Lukerganj and Mutthiganj are observed to be above desirable limit of 300mg/l as per Figure 6. Turbidity of Beniganj area is observed to be 42.5 NTU, which is very high as compared to the acceptance limit of 5 NTU (Figure7).

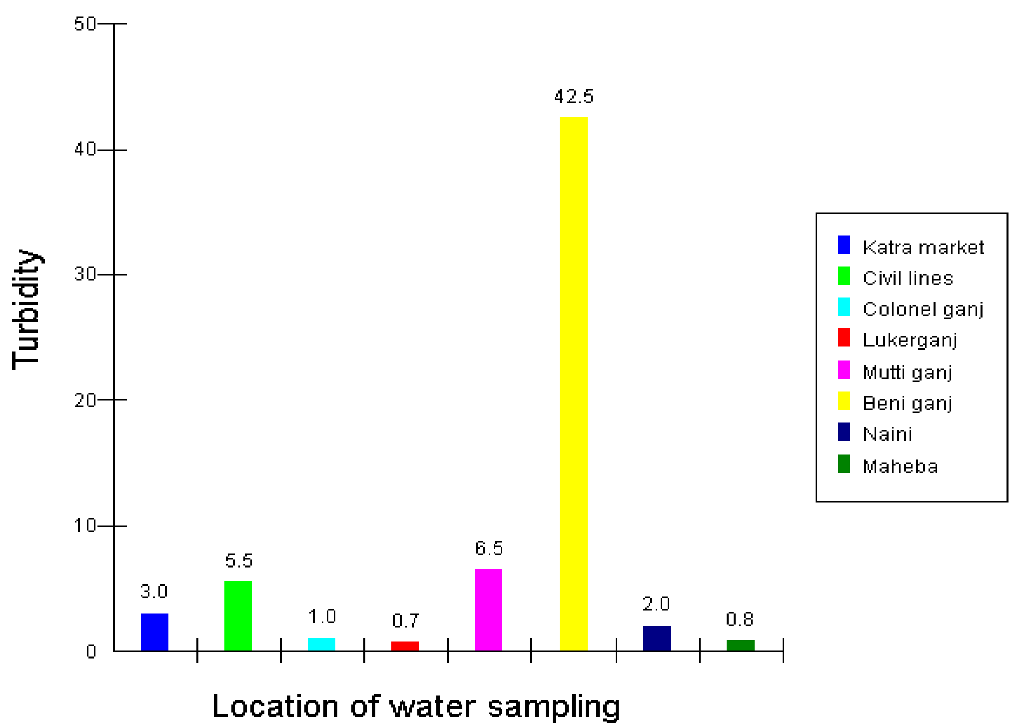

Figure 7: Turbidity at hand pumps in summer season

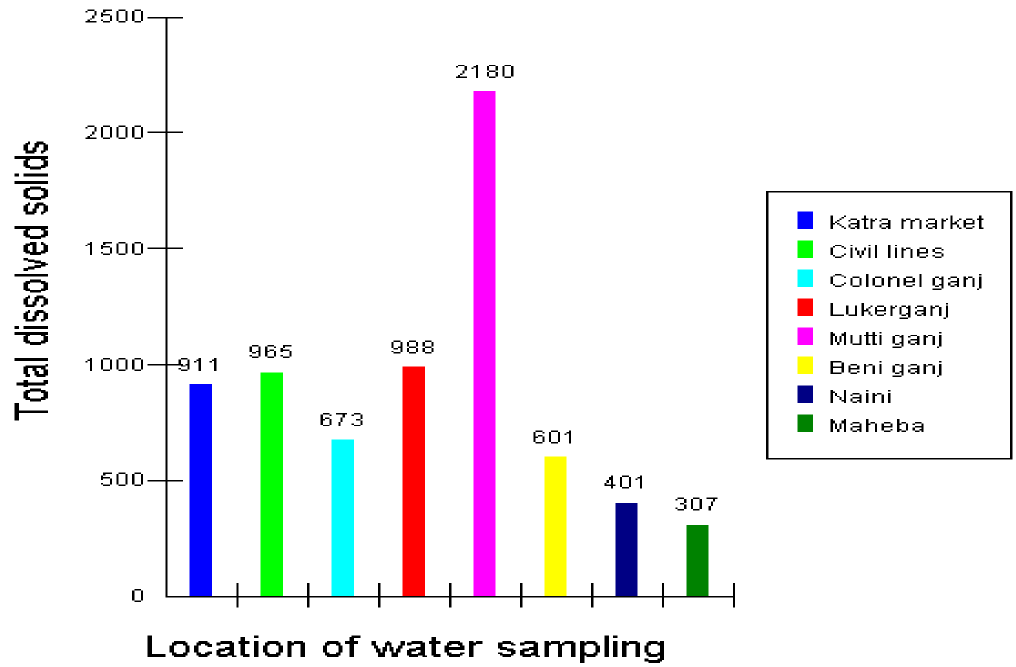

Figure 8: Total dissolved solids at hand pumps in summer season

It has been observed that total dissolved solids are above desirable limit at Civil lines and Mutthiganj (Figure 8).

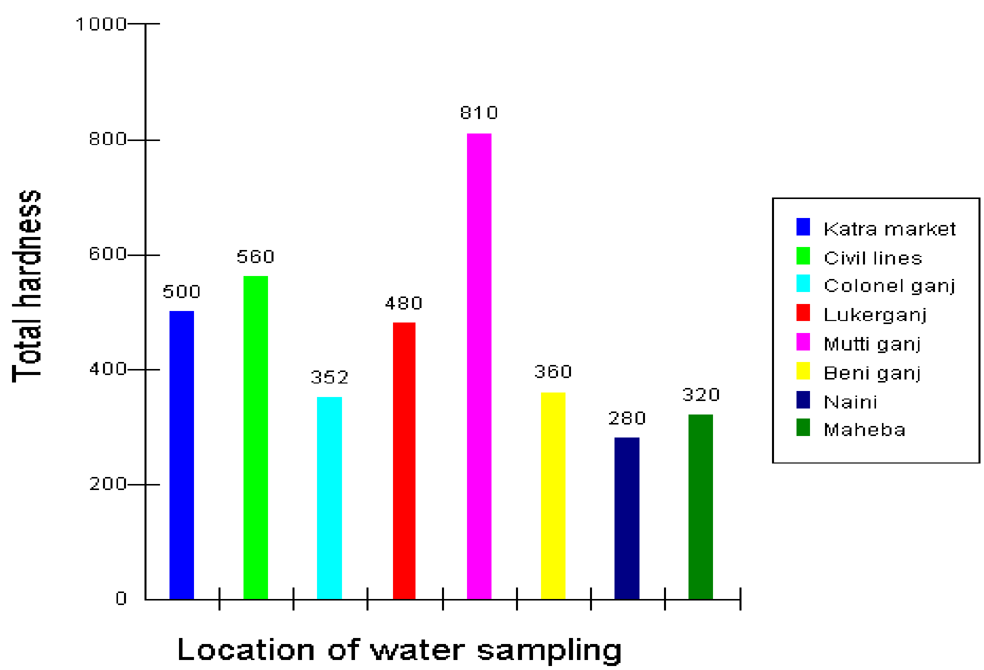

Figure 9: Total hardness at hand pumps in summer season

The hardness level is above its permissible limit in all areas except Naini and Maheba as per Figure 9. In the summer season, total coliform are found in Katra market, Naini, Mutthiganj and Civil lines. Further, the Katra market shows high TC value of 25 CFU/100ml.

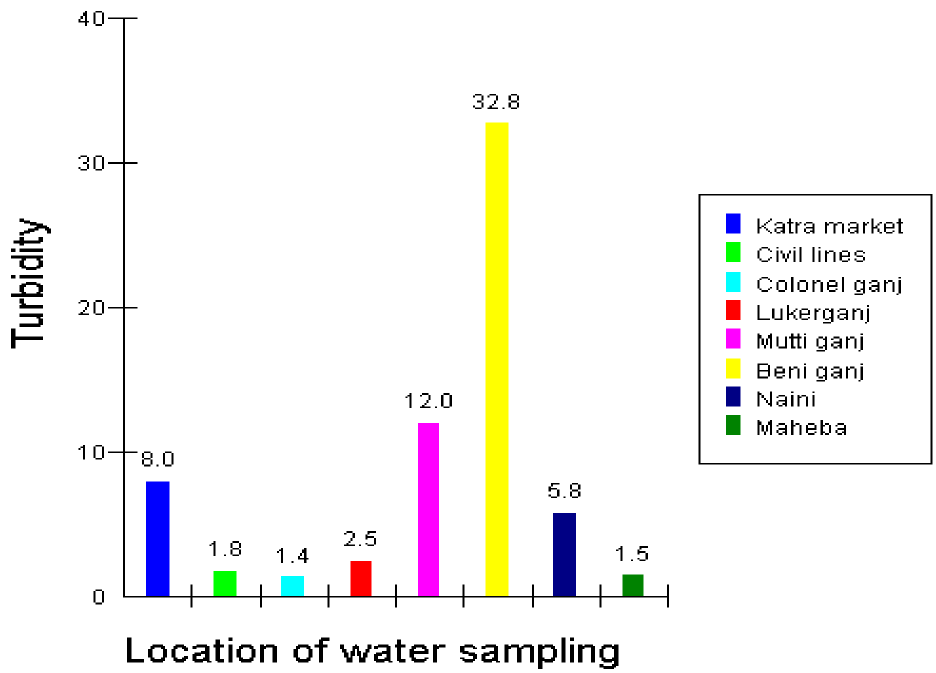

Figure 10: Turbidity at hand pumps in winter season

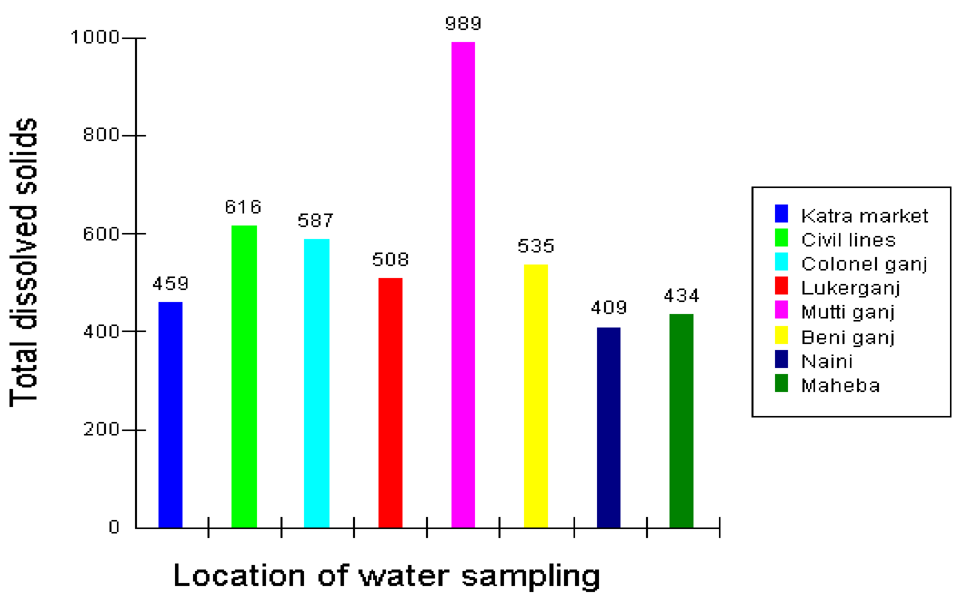

Figure 11: Total dissolved solids at hand pumps in winter season

Turbidity is observed as very high in Beniganj hand pumps water (Figure 10). Further, Mutthiganj and Beniganj locations show the turbidity level which is higher than its permissible limit. From Figure 11, it has been observed that total dissolved solids are in permissible limit except in Mutthiganj.

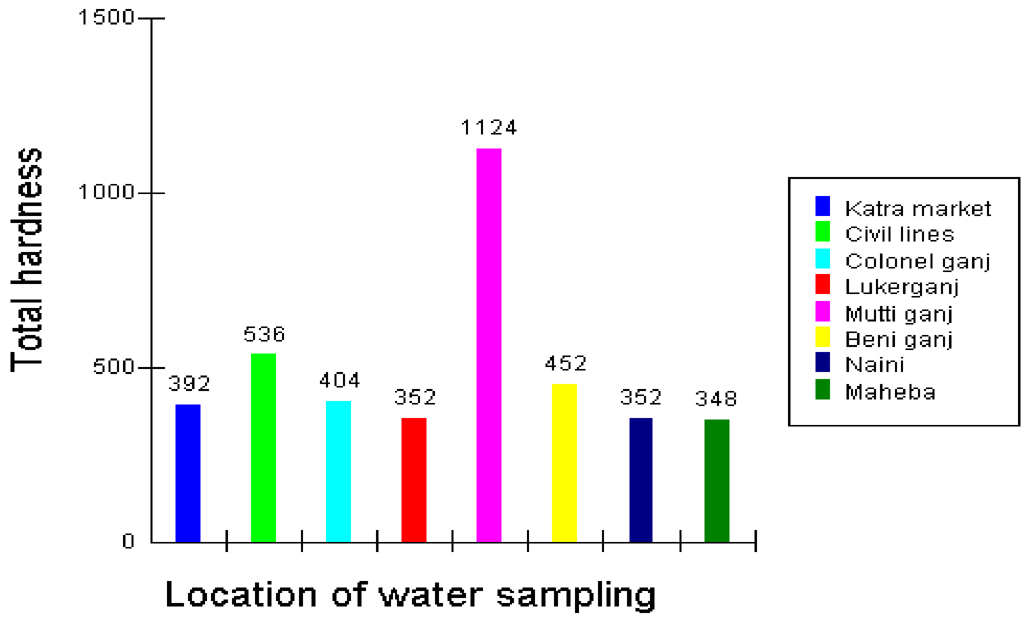

Figure 12: Hardness at hand pumps in winter season

It can be seen from Figure 12 that all the locations have hardness concentration above the desirable limit of 300 mg/l.

4.0 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 has given the spatial, graphical and statistical representation. The results of water quality mapping of Allahabad city shows that nearly 30% of sources are non potable due to physiochemical or bacteriological reasons or both in the case of tube wells. Based upon the analysis carried out, it may be concluded that almost all the hand pumps require treatment of water for bacteriological contamination to make it safe for drinking or else the consumption of this water may be stopped to reduce the outbreak of health hazards.

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