CHAPTER 1

INTRODUCTION

1.1 GENERAL

Globally, billions of people lack access to safe water and adequate sanitation. About 40% of the world’s population lacks basic sanitation and sanitation coverage is commonly much lower in rural areas than in urban areas (WHO 2002). Estimates of the World Health Organization (WHO) and the Water Supply and Sanitation Collaborative Council indicate that 25% of the urban dwellers in developing countries lack access to sanitation services with a much higher percentage for the rural populations of developing countries reaching up to 82%.

The WHO (2002), estimates that 2.1 million people die annually from diarrhea disease. Worldwide, significant development has been made in management and treatment of solid waste and wastewater. Especially treatment of wastewater is one of the major investments due to high capital cost in addition to operation and maintenance cost. Also, operation of wastewater treatment plants in developing countries is getting costlier and the availability of funds from the government and local budgets is inadequate. However, small and isolated villages or settlements with low population densities can be served by decentralized systems that are simpler and more cost effective. The large capital investment of sewerage system and pumping cost associated with centralized system can be reduced, thus increasing the affordability of wastewater management systems.
1.2 IMPACT OF URBANIZATION

Water scarcity is the major issue which is observed all over the world. The main causes of water scarcity in developing countries like India are rapid urbanization, industrial growth, increase in population growth, migration of rural population to urban and peri-urban areas and climate change. Urbanization is an index of transformation from traditional rural economies to modern industrial one (Parkinson and Kevin Tayler 2003). The growth of urbanization is rapid in low income countries. The majority of urban growth is associated with the rapid expansion of smaller urban centers and peri-urban developments. Much of this growth is unplanned and informal with community members and informal sector developers taking advantage of the fact that the regulatory capacity of government authorities is weak particularly in those areas that are outside the official municipal boundaries (Ravindra Kumar Verma et al 2008). Such unplanned and informal settlements of different class people in peri-urban areas are due to high living cost and land cost in cities.

Peri-urban areas are characterized by a mixture of different economic class people. Settlement of higher economic people is observed in well planned locations, where infrastructural facilities like water supply, electricity, bus station, schools, colleges, hospitals, etc. are all available. On the other hand, the settlements of middle and lower class people are found in unplanned peri-urban areas, where the above mentioned infrastructure facilities are either not available or inadequate. Moreover, wastewater treatment plants, either centralized or decentralized are not available in those suddenly expanded areas, due to lack of funds with the government (GTZ 2009).

In peri-urban areas, increasing populations, combined with increasing water consumption and a proliferation of water borne sanitation,
create widespread wastewater disposal problems. In many cases, wastewater is discharged locally onto the open ground and vacant plots, creating ponds of foul-smelling stagnant water. Children and others may come into contact with polluted water, especially as they often play in open areas where wastewater and refuse get collected. Health risks are increased by the fact that household sewerage and surface water drainage systems are invariably combined so that floodwater becomes contaminated with excreta. Mosquitoes and other pests breed in blocked drain and ponds, spreading diseases such as filariasis.

1.3 CENTRALISED WASTEWATER TREATMENT SYSTEMS

Centralized systems are usually well planned, designed and operated by government authority which collects and treats large volume of wastewater for large communities thus making use of large pipes, major excavations and manholes for access (Massoud et al 2009 and Ligy Philip 2012). The major disadvantage of centralized wastewater treatment system is the investment of high capital cost for construction and as well as for large pipe network system. It requires technically qualified persons to operate the system in effective way.

1.4 DECENTRALISED WASTEWATER TREATMENT SYSTEMS

Tchobanoglous (1996) defined decentralized wastewater management as the collection, treatment, disposal and reuse of wastewater from individual homes, clusters of homes, isolated communities, industries, or institutional facilities, as well as from portions of existing communities at or near the point of waste generation. Crites et al (1998) defined that decentralized management of wastewater, is the collection, treatment and reuse of wastewater at or near the point of generation.
In urban and peri-urban areas, the decentralized wastewater treatment system provides permanent solutions to the communities which lacks in management of wastewater. Wastewater generated by the population living in rural areas is typically collected, treated, and disposed or reused at the household level using onsite facilities (Kara Nelson 2002). They can provide primary, secondary and tertiary treatments for wastewater from sanitation facilities, housing colonies, public entities like hospitals, or business and reuse options (Ajit Seshadri 2009). If these decentralized systems are to be permanent solutions, then there must be adequate land available at their sites to facilitate repair, replacement or expansion in the future (Massoud 2009).

The advantages of decentralized wastewater treatment systems are investment of less cost for construction with easier maintenance is achieved. Efficient treatment of wastewater generated from domestic level, industrial level and commercial level results less environmental degradation. Public participation is observed more in maintenance and management of decentralized treatment systems. Treated wastewater can be reused for various purpose like recreation, car washing, toilet flushing, landscape irrigation, fisheries, agriculture and groundwater recharge. On the other hand disadvantages of decentralized wastewater treatment system are requirement of land near by the generation point of wastewater is difficult. Maintenance and operation of treatment system requires skilled people. Soil properties and environmental factors influences more in selection of decentralized treatment systems.

1.5 WASTEWATER REUSE

According to United Nations Secretary-General High-Level Panel on Global Sustainability (2012) states that, the worlds population is likely to grow by 30% between 2000 and 2025 and by as much as 50% between 2000
and 2050. This results in increase of water usage and demand of surface water and groundwater. To meet freshwater demand, alternate and reliable source of treated or reclaimed wastewater is recommended. Hence, recreating adequate water supply and utilizing wastewater become important issues in sustainable urban development. The volume of wastewater is estimated to be 70% to 80% of the freshwater consumption by the population (WHO/UNICEF 2010). This constitutes an enormous water resource if appropriate wastewater reuse schemes are implemented.

WHO (2006) states that in Asia, only 25% of urban wastewater is effectively treated and the remaining 75% of untreated wastewater is discharged into the nearby surface water bodies and ground water systems. Wastewater reclamation and reuse are becoming important components of the management of urban, regional, and national water resources. Water recycling and reuse have become promising alternatives to meet the needs for supply of fresh water as well as to minimize increasing problems linked to the contamination of groundwater due to pollution. Treated wastewater has a special importance in maintaining and increasing water resource, as well as in improving the quality of the environment.

1.6 ARTIFICIAL RECHARGE USING RECLAIMED WASTEWATER

Artificial recharge is the planned, human activity of augmenting the amount of groundwater available through works designed to increase the natural replenishment or percolation of surface waters into the groundwater aquifers, resulting in a corresponding increase in the amount of groundwater available or abstraction.

Artificial recharge using reclaimed wastewater is an emerging technique which is getting its importance world wide. The main advantage of artificial recharge through reclaimed water is to control saltwater intrusion, reduce land subsidence, maintain stream base flows, or similar in-ground functions (CGER 1994).

CGWB (2000) address the major issues of artificial groundwater recharge using reclaimed wastewater, which are listed below:

i. To enhance the sustainable yield in areas where over-development has depleted the aquifer.

ii. Conservation and storage of excess surface water for future requirements, since these requirements often changes within a season or a period.

iii. To improve the quality of existing groundwater through dilution and

iv. To remove bacteriological and other impurities from sewage and wastewater.

1.7 SOIL AQUIFER TREATMENT (SAT)

Natural treatment of treated wastewater and recharge is achieved by a popular technique called Soil Aquifer Treatment. A schematic representation of soil aquifer treatment is provided in Figure 1.1. During this process continuous ponding of primary or secondary or tertiary treated wastewater is allowed to infiltrate into the soil system. During the initial infiltration process, the top most layer or the unsaturated soil layer will act as a filter media where the most of biodegradable materials, harmful viruses, bacteria, chemical and physical parameters can be removed. Soil-aquifer treatment is essentially a low-technology, advanced wastewater treatment
system (Bouwer 1985). Soil-aquifer treated wastewater also has an aesthetic advantage over conventionally treated waste water. The water recovered from an soil aquifer treatment system is not only clear and odour-free it also comes from a well, drain or via natural drainage to a stream or low area, rather than from a sewer or sewage treatment plant (FAO 1992).

![Schematic Representation of Soil Aquifer Treatment (SAT)](image)

Source: FAO 1992

**Figure 1.1 Schematic Representation of Soil Aquifer Treatment (SAT)**

### 1.8 SOIL PROFILES FOR SAT

Soil Aquifer System works excellent in soils that are permeable in nature. During SAT process, top layer of the soil of thickness 5 cm to 30 cm acts as filter media to filter all the impurities. However, soils which are coarse in nature can pass the pathogenic substances, bacteria and viruses very quickly into the unsaturated zone leading to contamination of regional water. Soils that are less coarse in nature such as fine sand, loamy sand and sandy loam are more suitable for SAT application. Clogging is the major issue in
SAT operation. It mainly depends on the factors like type of soil, quality of reclaimed water, ponding depth, wetting and drying cycle etc. (FAO 1992).

1.9 USES OF SOIL AQUIFER TREATMENT SYSTEM

1. Additional treatment for the recycled water as it is naturally purified to a better standard and filtered through the earth.

2. Main reason of operation of SAT basin with wetting and drying cycles, that the breeding of mosquitoes will be avoided.

3. Water is not wasted through evaporation and

4. Water can be stored underground for years

Source: Bouwer (1985)

1.10 GEOGRAPHIC INFORMATION SYSTEM

Geographical Information System (GIS) is a database management tool used to manage a large volume of spatial and non-spatial data. GIS integrate several components to analyze any spatially referenced data. Overlay analysis is one of the simple and effective techniques in GIS to combine different thematic layer map into one. This approach is often applied to find suitable locations for a particular use. Selection of suitable Decentralized Wastewater Treatment Plant sites has been done using GIS based multicriteria analysis using the overlay techniques of different thematic maps for the study area.

1.11 NEED FOR THE STUDY

The expansive growth of population in the urban and peri-urban areas in the past few decades results in significant water and wastewater
problems. Poor waste water management systems coupled with hot climatic conditions results in increasing environmental problems with significant local as well as global dimensions. The need of the hour is to devise an efficient waste water management system wherein decision-makers and waste management planners can deal with the increase in complexity, uncertainty, multi-objectivity, and subjectivity associated with this problem. Therefore it is necessary to develop an environmentally sustainable and efficient wastewater treatment and management systems. The wastewater generated in Shollinganallur Taluk is mainly discharged in septic tanks and near by open surface water bodies. During heavy rainfall seasons the improper disposal of wastewater creates environmental problems like spreading health hazard disease, groundwater pollution and breeding of harmful insects like flies and mosquitoes etc.

To upgrade wastewater treatment in an area, the first choice usually suggested is to build a centralized collection and treatment facility. However, centralized collection and treatment may not be the right answer for every community’s wastewater disposal needs. Small communities often cannot afford these expensive facilities and the population may be too spread to make centralized treatment a realistic option. Additionally some existing onsite systems may function effectively, so they don’t need to be replaced. In these circumstances decentralized wastewater treatment is often the best solution for wastewater management. Decentralized wastewater treatment system uses a combination of traditional and innovative treatment technologies.

Selection of a safe decentralized waste water treatment system requires an extensive evaluation process in order to identify the best available disposal location. This location must comply with the requirements of government regulations and at the same time must minimize economic,
environmental, health and social costs. The site selection procedure, however, should make maximum use of the available information and ensure that the outcome of the process is acceptable by most stakeholders. Therefore, decentralized waste water treatment system site selection generally requires processing of variety of spatial data.

The present study focuses on a suitable landuse site selection based on multi-criteria decision analysis and geographic information system based overlay analysis. The most appropriate decentralized waste water treatment system site has been identified for Shollinganallur Taluk of Kancheepuram district, a typical peri- urban area of Chennai City Development region. Several important factors and criteria were considered to arrive at the suitable Decentralized Treatment Plant site selection including the pre-existing land use, location of sensitive sites, water bodies, water supply sources, groundwater quality, soil type, population density, geology and wastewater quantity. Thematic maps of the selected criteria were developed within the paradigm of standard GIS software. Subsequently, weights were assigned to each criterion depending upon their relative importance and ratings in accordance with the relative magnitude of impact.

A GIS based Multicriteria Analysis using Analytical Hierarchy Process (AHP) model was developed for suitable site selection of decentralized wastewater treatment plants for the study area. In the AHP model a matrix form was developed for the criteria. The input given to each criterion matrix is the weights suggested by the panel of experts. The AHP allows some inconsistent and there by ratio scales were derived from the principal eigen vectors and the consistency index is derived from the principal eigen value.

Once the potential site selection of decentralized wastewater treatment system has been done, each decentralized waste water treatment
system is analyzed for reuse options in order to supplement the groundwater sources. The reuse of wastewater refers to the use of treated municipal wastewater as source of supply for nonpotable uses and recharge purpose for potable use. The non potable reuse includes landscape, agriculture irrigation, industrial use, vehicle washing, toilet flushing, air conditioning etc.

The potable reuse of wastewater was achieved by recharging the reclaimed wastewater through ground surface, where biopurification and geopurification process will take place as water pass through the vadose zone layer. This is generally known as Soil Aquifer Treatment system. For recharging with reclaimed wastewater, the parameters like type of the soil, depth of the soil, quality of influent water and groundwater plays major role. The final quality of effluent obtained after SAT indicates that a field or basin is suitable for further development of SAT system in that basin. A short term soil column test was conducted to study the water quality improvement during SAT system in order to recommend the study area suitable for SAT basin or not.

1.12 OBJECTIVES

1. To carry out GIS based Multicriteria Analysis using AHP model for suitable site selection of decentralized wastewater treatment plants for the study area.

2. To identify suitable wastewater treatment technology and reuse options for decentralized treatment plant sites.

3. To evaluate the sites of Decentralized Treatment Plants for the application of Soil Aquifer Treatment method.

4. To study the performance of Soil Aquifer Treatment System using soil columns in improving the reclaimed wastewater quality.
1.13 ORGANISATION OF THE THESIS

The presentation of the thesis work is planned in six chapters. The Chapter 1 introduces the background, motivation and objectives of the research. A detailed review of earlier work done related to the sustainable management of wastewater, groundwater recharge techniques, specific capabilities of GIS software and multicriteria decision analysis in solving wastewater disposal problems in urban and peri-urban areas have been discussed in Chapter 2. In Chapter 3, the area chosen for this study has been described. The detailed methodology for selection of decentralized wastewater treatment plants using GIS based multicriteria analysis and various reuse options for the selected decentralized wastewater treatment plants are presented in Chapter 4. The Chapter 5 illustrates detailed development of methodology with field survey data, GIS analysis and laboratory study results and findings. The summary of the present study along with the conclusion drawn out of the present work and recommendation for future work are presented in Chapter 6.