Chapter 1

Introduction

1.1 General

urbanization became an irreversible global change during the 20th century (UNFPA, 2007). Although urbanization has been considered very important for the economic development, urbanization, especially rapid urban development in currently developing countries has had negative impacts on environmental quality at local, regional, and global scales (IHDP, 2005). Drastic conflicts between scarcity and pollution have made water resources a key restricting factor for sustainable urbanization processes (Bao and Fang, 2007). Water security has become a political issue in some regions (OECD, 2005) as a result of land cover change and intensified human activity from urbanization (Butler and Schutze, 2005; Olivera and DeFee, 2007).Urbanization is taking place at a fast rate in India. Population residing in urban areas in India, according to 1901 census, was 11.4% (Singh K.N, 1978). This count increased to 28.53% according to 2001 census, and crossing 30% as per 2011 census, standing at 31.16% (Datta, Pranati, 2012; Business Standard, 2012).Increase in urbanization level is causing threat to the quality of waters in rivers, lakes and ponds in India.

1.2 Introduction

There exists an intrinsic relationship between urbanization and surface water quality. Fast growth in population, more effective agriculture and industrial development are the main reasons for the growing amount of pollutants in the waters. Wastewater from the human settlements contains organic material and nutrients, industrial wastewater contains heavy metals and complexes, insoluble chemical compounds, which are harmful to people, animals and plants. Fertilizers and pesticides are used in the agriculture and they are harmful for the surface and groundwater, traffic loads air, soil and water and irrigation burdens water with salt. In the developing countries these agglomerations are even worse than in developed countries because they do not have proper sanitation and the technique are often too old and noneffective (Bowman 1994). In the context of effective urban resource planning and management, the recognition of the impacts of urbanization on the water environment is

among the most crucial. The significance stems from the fact that water environments are greatly valued in urban areas as environmental, aesthetic and recreational resources and hence are important community assets. Arguably it is the water environment which is most adversely affected by urbanization. (Goonetilleke, Ashantha ,Thomas, Evan C.,2004)

Although the relationship between urbanization and surface water quality is difficult to appraise, is simple to comprehend. Urban areas contain many people in relatively small areas, and the activities of these people produce pollutants and cause pollution. Some pollutants are discharged into the surface water bodies affecting quality of surface water. Thus uncontrolled urbanization poses major challenge to maintaining quality of surface water bodies.

 In a river system, the river and tributaries flows through its catchment area. Thus the quality of a river is affected by the urbanization of the catchment area. Hence, the correlation between the surface water quality at various locations and the urbanization of the catchment area of each of these locations is required to be established for evaluating the impact of urbanization on surface water quality.

In the present research carried out, a model is developed to investigate the urbanization influence on river water quality. Quantitative measures for the water quality act as a tool to determine condition of the water quality and quantitative measures of urbanization provide mechanism for evaluating urbanization levels. Water Quality Index and Urbanization Index has been employed to summarize the water quality and urbanization respectively into a single score in this study. Furthermore, correlation between water quality and urbanization of the catchment area is evaluated. Once the correlation between water quality and urbanization is established, a regression model is then developed to predict the water quality for the future growth of urbanization.

In the present research study, after identification of indicator parameters for water quality (six in this study), the Water Quality Index model has been formulated. Six physico-chemical and biological water quality indicator parameters, namely, pH, Dissolved Oxygen (DO), Biochemical Oxygen demand (BOD), Electrical Conductivity(EC), Nitrate Nitrogen and Total Coliform are selected for formulating the Water Quality Index model.

To evaluate the urbanization level of a district, the urbanization Index model has been developed by identifying four multi-dimensional aspects of urbanization, namely, demographic aspect, economic development aspect, spatial aspect and infrastructural development aspect including physical and social infrastructures. Under the four aspects identified, nine indicator parameters of urbanization are selected namely, population size, population density, number of Industries, percentage of built- up area, roofing types, electricity facilities, educational facilities, availability of health services and assets (i .e, T V, computer/ laptop, telephone/mobile phone and scooter/car.) The Urbanization Index model for districts has been formulated using the nine indicator parameters of urbanization. From this model, a methodology is developed for deriving Urbanization Index of the catchment of the stations.

The Water Quality Index model and the Urbanization Index model developed are applied to five stations located on the Sabarmati River and its tributaries in the Sabarmati river basin. The calculated values of Water Quality Index (WQI) of the stations and Urbanization Index (UI) of the catchment area of the stations are used to develop the Water Quality- Urbanization Regression model (WQURM). The WQURM is a model to predict the water quality of a station for the future urbanization level of the station in a river basin.

1.3 Motivation for the present study

The increasing threat of deterioration of surface water bodies with the increasing pace of urbanization needs to be addressed critically. Deteriorating water quality leads to increased treatment costs of potable and industrial waters. Non-point sources of pollution also introduce a wide range of potentially infectious agents to water that may be supplied to many rural communities, thus resulting in incidences of waterborne diseases with far reaching socio-economic implications. There is a need to investigate the urbanization influence on the nearby river water quality. Therefore, the main objective of this research has been to evolve a suitable model to quantitatively correlate the urbanization and water quality based on appropriate water quality parameters and urbanization parameters. The model evolved can be used as a tool to predict the changes in the river water quality of a city located in the river basin in the pace of urbanization. Based on the output of the model, policies can be proposed

by policy makers to solve the water quality deterioration problems, and to promote the urbanization processes in a scientific manner.

1.4 Objectives of the study

The objectives of the research are:

- To evolve Water Quality Index model for the measurement indicator of water quality of a river.
- To evolve Urbanization Index model for the measurement indicator of urbanization of districts.
- To develop a methodology to evolve the Urbanization Index of the catchment area of the stations in a river basin.
- To establish a correlation between surface water quality parameters and urbanization.
- To develop the Water Quality- Urbanization Regression model (WQURM)
- To apply the WQURM model to a river basin for predicting the water quality of a location for the future urbanization development in a river basin.
- To study the water quality at different stretches of the Sabarmati river.
- To compare the seasonal and spatial variation of water quality at various stations in the pace of urbanization.

1.5 Organization of the thesis

The thesis is organized into six chapters.

Chapter 1 introduces the problem and the relevance of present study in the context of assessment of water quality for the impact of urbanization. The motivation and the objectives of the study have been described.

Chapter 2 presents a review of the relevant literature with reference to earlier studies related to assessment of water quality and urbanization and the impact of urbanization on water quality.

Chapter 3 describes the development of three models, namely,

1. Water Quality Index model, which is a measure to assess the status of quality of a surface water body.

2. Urbanization Index model of the catchment of station on the river, which is a measure to assess the urbanization level of the station location and

3. Water Quality- Urbanization Regression model (WQURM), which is a model to predict the quality status of surface water body for an estimated urbanization level of the location under study.

Chapter 4 describes the application of the models developed on the Sabarmati River basin, Gujarat, India. The chapter first describes the overview of basin, tributaries of the Sabarmati river, its salient features, pollution status and perennial status of the Sabarmati river. The data base for water quality parameters and urbanization parameters for Sabarmati river basin are presented. Next, the application of the Water Quality Index model, Urbanization Index model and Water Quality - Urbanization Regression model (WQURM) is demonstrated on the Sabarmati River basin.

Chapter 5 presents the results and discussions from the three models developed in this study.

Chapter 6 presents validation of the three models formulated in the research. The validation of Water Quality - Urbanization Regression model (WQURM) is carried out on the Mahi river basin, Gujarat, India. Also, the salient features of Mahi river basin are described and the data base for Water Quality parameters and urbanization parameters for Mahi River Basin is presented.

Chapter 7 presents conclusions derived from the present research and significance of the research is elucidated.