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Quantitative Analysis and Statistical Modelling of Water Consumption of Five Star Hotels in Delhi, India

SIDDHARTHA GAUTAM[1], SIRAJUDDIN AHMED[2+] AND AASTHA DHINGRA[3]

Five star hotels are intensive users of fresh water resources. This study investigates various independent variables affecting water consumption. Water consumption modelling and its validation have been undertaken. Twenty seven hotels operating in Delhi were selected for collection of relevant data through a questionnaire and field survey. Statistical analysis has been carried out using the Statistical Package for Social Sciences (SPSS) software and R-software for principal component analysis (PCA) to identify influential variables in respect of the water consumption pattern. The three water consumption equations, in terms of total water consumption, consumptive uses and non-consumptive uses, have been developed using multiple regression analysis. These equations have been able to explain the 85%, 82% and 78% respectively of the original variability. These developed equations for determining the water consumption are useful to reduce the freshwater usage and to promote reuse of treated wastewater for non-potable purposes.

Key words : *Water resources, hotel industry, water consumption, consumptive and non-consumptive usage, sustainable development, statistical modelling of water consumption*

1.0 Introduction

Delhi, the capital of India is located in sub-tropical region wherein temperature from March to October varies between 35 to 45 °C, with humid conditions. During this period, the potable water consumption is also high. An estimated two hundred million people spread over 1483 km^2 of the city – making it one of the most densely populated cities of the world.

In this age of economic globalisation, to the increased business opportunities and higher GDP rate has given a big boost to the tourism industry. During the last decade, the city has seen a manifold increase in the number of five star hotels. According to the record of Delhi Pollution Control Committee, there were 50 fifty five star hotels in the city in the year 2015. The hospitality sector of Delhi, is contributing to its economic growth, resulting on enormous rise in the consumption of natural resources. During the period 1995 to 2013, India's tourists inflow increased by two times, over the global average[1].

Hotels constitute an important part of tourism sector, and thus, their role in sustainability of water resources management is essential. Therefore, water consumption in the hospitality sector needs to be properly managed. Five star hotels, swimming pools, laundry, guestrooms, horticulture, lawns are main consumers of water. Hotel consumes water at a rate of 500-800 L/G-N, which is around 4-6 times the average water consumption per capita per day in India. The present study has been aimed at statistical analysis of water consumption pattern, including consumptive and non-consumptive use.

1.1 Water consumption pattern: Five Star Hotel

The water consumption pattern in five star hotels has been categorised into the consumptive and non-consumptive use, depending upon quality of water and social acceptability. Consumptive use includes water consumption in kitchens, laundry, bathrooms, guestrooms, swimming pools and boilers (where only potable freshwater can be used). Non-consumptive includes water used in horticulture/gardening, flushing, cooling towers, make up water and road washing and allied activities.

1.2 Water consumption practices:An international scenario

There is a need to identify the dimensions of environmental performance of the hotels by benchmarking the resource consumption. The water use rating for hotels of 150 and more rooms for < 666 l/G-N as 'good', 666 – 855 l/G-N as 'fair', 855-980 l/G-N as 'poor' and > 980 l/G-N as 'very poor'[2].

European hotel chain consumes water at a rate of 440 litres per guest-night[3]. The general benchmarking for water consumption in hotels has been developed and, accordingly, classified the consumption into two categories, viz., (i) base-line water consumption of 700 l/G-N and (ii) best practice of ≤ 500 l/G-N[4]. The International Hotels Environment Initiative,

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Impact of Urban Settings on Girudhumal River in Madurai (India)

GNANAVEL BALAJI + AND KESAVAPERUMAL THIRUMARAN

Maintaining the character of a river channel is vital in semi arid regions experiencing the urban development. Madurai's urban population is increasing at the rapid phase and the estimated urban population is likely to be around 23 lakhs in the year 2031. Most of the present urban sprawl is in the drainage catchment area of the Girudhumal River (GR). The paper aims to raise the level of concern paid to the urban river channel issues and urban development process in Madurai. Results show that urban expansion had a significant impact on GR and its riparian zones. Change due to the influence of urbanization on GR involves reduction in length nearly to 0.5 km and width nearly to 10 m. Considerable loss of riparian landscape in Stretch II and Stretch III and increase in sediment deposit on stretch IV may contribute the under evaluation of this river thereby increasing the likelihood of further impact taking place. The studies on land use patterns and interventions on GR from 1990 were carried out using detailed survey map, land use maps, Google imagery, topography sheets of scale 1:50,000, 1:25,000.This study is considered as a first step towards understanding the impact of Madurai urbanization on river channel course.

Key words: *Girudhumal River, Madurai, Urbanization, Impervious Surface Area (ISC).*

1.0 Introduction

The main focus of this paper is to investigate and understand the impact of urbanization on Girudhumal River (GR) within the Madurai urban limits in terms of its physical and geometrical dimensions. Madurai, the second largest urban center in the state of the Tamil Nadu, India is situated on the latitude 9°55' North and 78°7' East having an average altitude of 130 m above the mean sea level. The city is situated on a multi-basined drainage pattern region with River Vaigai and River Girudhumal bisecting the city. Presently there are two rivers (namely River Vaigai and River Girudhumal) and eight channels (both surplus and feeder) within the urban limits of Madurai. These networks of water systems had sustained for centuries till the advent of sporadic urbanization in early 1970's. Most of the urban rivers in this part of the state act as a drainage channels disposing the urban waste waters. During heavy monsoon, these channels carry the flashy floods from River Vaigai to the Tanks outside the city, then to the sea. Remaining days these channels carry sewage flows from the city to the tanks. In present situation, Girudhumal River is the drainage life line of Madurai city, particularly for the important residential and commercial areas of the southern part.

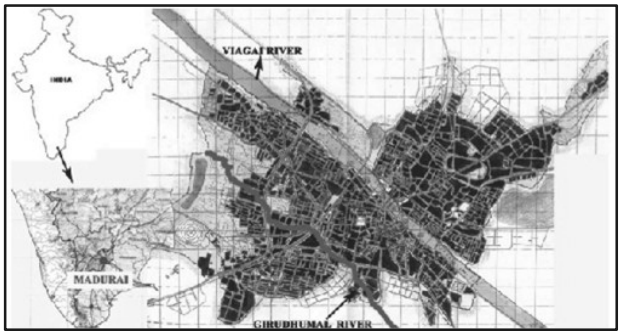

Fig. 1 : Setting of River Girudhumal in the city along with River Vaigai

The topography of Madurai region clearly exhibits numerous low level lands characterized by shallow depressions and lakes that served as water resources from historical times. These tanks are well connected to rivers. The abundance of water from the River Vaigai is fed into small natural water tanks and streams. There are innumerable tanks and surplus/ supply channels on both sides of River Vaigai. The GR is one such surplus/ supply channel in the region. The length of this river is 88 km feeding 75 tanks in the middle reach. Throughout its length it acts as surplus for many cascade of tanks in the region and also it is one of the few rivers that act as inter basin transfer between Vaigai basin and Gundar basin.

1.1 Importance of the study

Complete change from agricultural use that contained water channels for drainage and surplus purposes to urban

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Seasonal Variation of Physico-Chemical Parameters of Different Sources of Water in Himachal Pradesh, India

SUNNY KUMAR[1], AJAY BHATIA[1], MAMTA KUMARI[1],
KUMAR BHARAT BHUSHAN[2], ARUP GIRI[1,3*]

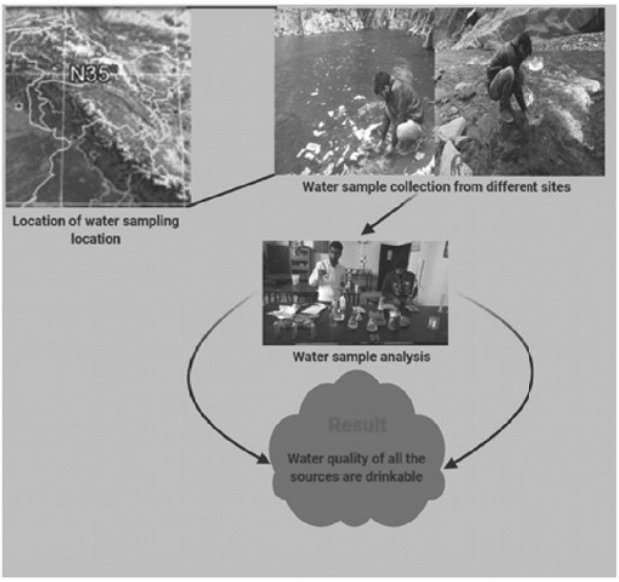
The present study was conducted in Himachal Pradesh, India, to determine the water quality of the various sources during the summer and winter seasons. Results showed that the pH and bicarbonate levels in the tap water and spring water were substantially higher ($p<0.05$) in the winter season. The levels of TDS, EC, DO, and chloride in all sources of water was slightly lower ($p<0.05$) in the winter season. The alkalinity of phenolphthalein, total hardness, and hardness of calcium, nitrate, sulfate, phosphate, and carbonate levels were not detected. All of the parameters belonged within the WHO defined limit. From these findings, it could be concluded that for drinking purposes, all the water sources are consumable. For the seasonal variation of microbiological load, minerals, and heavy metals profiling in all water sources in this region, a further extensive study should be carried out.

Key words: Physico-chemical parameters, River water, Seasonal variation, Spring water, Water quality

1. Introduction

Every organism that lives on this earth depends on the water. There will be no life on earth without water. Good water quality is an important thing for good health, and we need to control our water supplies. Otherwise, their availability and quality may cause problems with water resources (Subba and Rao, 1995). The physicochemical characters and water's biological properties are indicators of the natural ecosystem's good health (Venkatesharaju *et al*. 2010). Groundwater supply is the world's primary source of water, and an estimated one-third of the world's population is using groundwater for drinking purposes (WHO, 2002). Amount of health risk issues is found in the developing countries. Both are linked to the poor condition of the water or their domestic use. This problem is one of these counties' Government's key intentions. Diarrhea is a major problem and regular in these countries (Mark *et al*. 2002). It is believed that 80 percent of the naturally available water is incapable of drinking or the agricultural processes and also for the industrial side. It is founded that around 1.1 billion people have no reach to renew their water supply sources. The mortality reports of deaths due to diarrhea are up to two million (yearly). It is attributed primarily to unhealthy water supply and poor hygiene (WHO, 2013; Moharir *et al*., 2002). In India, the 95 percent rural population relies on groundwater for their domestic and essential use. They are also polluted; it is estimated that 70 percent of water resources are severely polluted, which has resulted in 75 percent of the disease and 80 percent of child health problems (Dasgupta & Purohit, 2001; Aris, 2009).

Monitoring the water quality of the various water bodies is a critical concern in deciding the quality of the drinking water, particularly in the high mountain area. Global warming is altering the pattern of global climate. High mountainous regions around the globe are also part of this



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Evaluation of Wastewater Quality Index for different Sewage Treatment Zones in Delhi, India

PRERNA SHARMA[1 (Ï)], SUDIPTA K MISHRA[2], SMITA SOOD[3]

Among the various methods adopted to foresee the performance of the Sewerage Treatment Plants (STPs), Wastewater Quality Index (WWQI) is the widely accepted index. The present study was conducted to evaluate the efficiency of the STPs in different sewerage treatment zones of Delhi. WWQI of twenty different STP's belonging to six sewerage treatment zones of Delhi were evaluated, WWQI for the effluent of these STP's was determined and the rating was given to each STP as per the widely used Canadian Council of Ministry of Environment (CCME) method. Highest WWQI value (76.014) was obtained for Rithala Phase I STP indicating a fair rating of the quality of wastewater as per CCME guidelines. The least WWQI value (34.786) was shown for Yamuna Vihar STP indicating poor rating. Impact of seasonal variations of all the STP's with different sewerage zones were also evaluated and Okhla Sewerage Zone shown the best results with respect to seasonal fluctuations. Whereas, Rohini STP had given the best treatment performance as obtained results showed and its influent and effluent WWQI value ranged from 40.43 and 99.899 respectively revealing excellent wastewater quality as per CCME guidelines. Overall, the present study evaluated the quality of wastewater in the different sewerage treatment zones of Delhi along with its seasonal variations and hence, can be used to estimate the suitability of the STPs falling in those zones and the need for maintenance and control for wastewater production of these plants.

Key words : *Wastewater Quality Index (WWQI), Water Quality Index (WQI), Canadian Council of Ministry of Environment (CCME), Sewerage Treatment Plants (STP's)*

1. Introduction

Water Quality Index (WQI) and Wastewater Quality Index (WWQI) are the widely acceptable indices for determining the quality of water as well as wastewater for their safe disposal into inland surface water bodies (Mudiya 2012). WQI gives an individual number obtained after the aggregation of the measurements of the water quality parameters (Shah *et al.* 2012, Limb *et al.* 2012). The disposal of effluents has adverse impacts on the receiving water body, land, health of the nearby residents as well as on the environment (Environmental Protection Agency Report, 2004, Amrisen *et al.* 2006). Effluent from the STPs cannot be properly reutilized as it contains harmful organisms such as *E. Coli*, bacteria but if treated nicely it can be used for irrigation, gardening etc. (Sharma *et al.* 2013, Singh *et al.* 2014). Studies showed that the discharge of the effluents, which are not appropriate in terms of their physicochemical parameters, is majorly responsible for the pollution in River Yamuna in Delhi (Foundation for Greentech Environmental Systems 2004, NRCD 2005, Yamuna action plan 2006a, Yamuna action plan 2006b). Hence WWQI is being developed to identify the quality of the waste or the effluents coming out of the various sewerage treatment plants (STPs) situated in Delhi.

Several studies have been conducted to develop WWQI based on the WQI. A study was conducted using the fuzzy rule base to determine the WWQI for the municipal wastewater treatment plant (Raut *et al.* 2017), and it focussed on developing WWQI which is helpful to optimise the various functional processes of the plant. However, no emphasis was given in the study on the criteria for obtaining WWQI as a purpose of safe effluent disposal. In a case study of river Ganga, Principal Component Analysis (PCA) was utilized for determining WQI, and had also defined the criteria for Ganga Water Quality Index (Tripathi *et al.* 2019). In another study carried out on sixteen water purification plants also used the Canadian Council of Ministers of the Environment (CCME) method for the classification of the raw and the treated wastewater for the treatment plants in Kirkuk Governorate using the water quality index (Salih *et al.* 2018). Canadian classification for water quality index has classified the quality of water under five classes ranging from "Excellent" to "Very Bad" each one of this class is given the categorical number from 1to5 respectively (Canadian Council of Ministry of Environment 2017). Finally, the WQI pertaining to the water quality classes and their respective category were assigned. The main parameters affecting WWQI of an STP for the

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Characterization and Performance Evaluation of Sewage Treatment Plants based on different technologies: A case study of Delhi, India

PRERNA SHARMA[1(*)], SUDIPTA K MISHRA[2], SMITA SOOD[3]

Sewerage Treatment plants (STPs) are considered as an important system in city infrastructure. Delhi NCR (in India) has a large number of STPs consists mainly of Extended Aeration, Activated Sludge Process (ASP), Sequencing Batch Reactor (SBR) and Densadeck/BIOFOR technologies. In order to compare and evaluate the performances of them, present study was carried out in Delhi NCR on various STPs based upon different wastewater treatment technologies. The samples were analysed for both influent and effluent for different physico-chemical parameters from the STPs and the effluent qualities were compared with Central Pollution Control Board (CPCB) standards in India. The study reveals that effluents from most of the STP's are meeting the permissible limits of CPCB and STP technologies played a significant role on its performance. Moreover, variation in monthly concentration in influent and effluent, which were depicted in the form of heat map graphs, indicates that most the physico-chemical parameters are highly correlated. Impact of seasons on the removal efficiency of the physico-chemical parameters were also performed and the plots indicate that the STPs based on Densadeck/BIOFOR technology shows less variations (over the seasons) while ASP technology shows the most. Finally, plots were also generated for integrated removal efficiency (using spider maps) which reveals that Densadeck/BIOFOR technology attained the highest rank followed by Extended Aeration and ASP technology respectively. Overall, analyses presented in this paper, may help in identifying the suitable STP technologies in Delhi NCR and elsewhere.

Keywords : *Sewerage Treatment Plants (STP's), Influent characterization, Removal Efficiency, Performance Evaluation*

1. Introduction

Sewerage Treatment plants (STPs) are considered as an important system in city infrastructure. Delhi National Capital Region (NCR) has a large number of STPs consists mainly of Extended Aeration, Activated Sludge Process (ASP), Sequencing Batch Reactor (SBR) and Densadeck/BIOFOR technologies. As the population of Delhi increasing rapidly (World Population Report 2018), effluent discharged from the STPs has increased substantially over the last couple of decades (Delhi Pollution Control Committee Report 2016). The disposal of effluents has adverse impacts on the receiving water body as well as on the surrounding environment (Environmental Protection Agency Report 2004, Amrisen et al. 2006). Moreover, effluent from STPs cannot be reutilized directly as it contains harmful organisms such as *E. Coli*, bacteria, but if treated nicely it can be used for irrigation, gardening purposes. (Sharma et al. 2013, Singh et al. 2014).

Studies carried out for evaluating the effectiveness of STPs in Delhi show that effluent from most of the STP's were improving gradually excluding Pappankalan, Coronation Pillar and Timarpur STP's which are based on SBR, ASP and Oxidation Pond technologies respectively (Gautam et al. 2013). Further studies revealed that the discharge of the effluents, which are not appropriate in terms of their physicochemical parameters, is majorly responsible for the pollution in River Yamuna in Delhi (Foundation for Greentech Environmental Systems 2004, NRCD 2005, Yamuna action plan 2006a, Yamuna action plan 2006b). Hence, it is important to know the effectiveness of different wastewater treatment technologies in a city to get effluent having desirable physiochemical parameters (Sato et al. 2006). Jamwal et al 2009, carried out performance evaluation of various STPs in Delhi emphasizing on Faecal Coliform, Most probable Number (MPN) and *E. Coli* removal efficiencies. Garrido et al. 2011, made a comparison of wastewater treatment technologies in Spain based on DEA meta-frontier model and revealed that the ASP technology was best in terms of technological and economic viability. But the study did not consider the latest wastewater technologies like Densadeck/BIOFOR. In Chandigarh India, some studies have performed comparative analysis of the STPs with different technologies and showed that the STP based upon MBBR

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Analysis of Soil Physicochemical and Trace Minerals of Two Different Sub-Tropical Regions of India

SHWETA KUMARI[1], PRIYA SHARMA[1], MAMTA KUMARI[1], AJAY BHATIA[1], NEHA KUMARI[1], KHUSHBOO BADHAN[1], SUNAINA CHANDEL[1], SUNNY KUMAR[1], SHIKHA GOMRA[1], INDU KUMARI[1], RAJESH KUMAR[1], AVILEKH NARIYAL[2], VIVEK TIWARI[3], AVANTIKA RANA[3], SOMEN ACHARYA[3], ARUP GIRI[1,3*]

This research was conducted in two separate sub-tropical regions of India to determine soil quality. All the soil samples were obtained from three separate sites, such as each region's agricultural field, roadside, and riverside forest. All samples were analyzed using standard methods for pH, electrical conductivity (EC), total solids dissolved (TDS), soil moisture (SM), water holding capacity (WHC), total organic matter (TOC), carbonate, magnesium (Mg), manganese (Mn), iron (Fe), copper (Cu), and zinc (Zn). Results indicated that the pH, TDS, EC, and Cu levels varied among Himachal Pradesh's three different sources. In Jammu, it was found that SM, SOM, and Cu level was varied among the sources. The study indicated that the pH of roadside soil, riverside soil was significantly ($p<0.05$) lower in the Jammu region than the Himachal Pradesh region. EC was substantially higher in all the sources of soil in the Jammu region than the soil of the Himachal Pradesh region. The study concluded that the roadside in the Jammu area showed a higher degree of pollution than that of Himachal Pradesh.

Keywords : *Agriculture, Himachal Pradesh, Jammu, Total organic carbon, water holding capacity*

1. Introduction

The entire ecosystem on this earth is made up of a dynamic soil system. The soil can also be described as part of the earth's crust containing humus (Hopkins, 1948; Gardiner & Miller, 2008). Soil is a finite, non-elastic, and non-renewable human-life asset that extends across natural resources. Soil is the most precious resource and the greatest gift of nature to humankind, as it takes 400-1000 years to form just one inch of topsoil (Twenhofel, 1945).

Rapid industrialization has posed a threat to the soil environment through emissions in recent years (Kiruba & Jeeva, 2010). This disparity has a reliable effect on plant performance and ecosystem performance (Huber-Sannwald & Jackson, 2001). A soil spatial study helps to describe the characteristics of the soil in the landscape, which is an act of vegetation, and other environmental factors are closely related (Maestre et al. 2006).

A significant factor in soil erosion is soil chemical fertility and then degradation (Bashagaluke et al. 2018), especially as a result of nutrient deficiency. However, little work has been done on micro-and macro-nutrient contamination, source identification, and spatial distribution of micro-and macro-nutrient contamination in subtropical soil in India. It's Thakur et al. (2019) carried out a soil report from Shimla and Kinnaur, Himachal Pradesh. The study indicated that the quantity of mineral was adequate. Sharma & Dogra (2011) stated that the plain area of Himachal Pradesh has sufficient mineral content. Bhatt et al. (2017) reported that the soils of the grape orchard have a higher level of iron, manganese, zinc, and a medium level of copper, boron, and molybdenum.

Very little literature is available on soil physico-chemical and mineral availability at two different altitudes in the subtropical region of India. The objectives of this study were, therefore (1) to analyze different physico-chemical properties and levels of minerals at two different altitudes, Jammu and Himachal Pradesh, India, (2) investigate the difference between the two altitudes based on different physicochemical and mineral levels.

2. Materials and Methods:

2.1. Study area:

The study was carried out in two different altitudinal regions (Jammu and Himachal Pradesh) of India. Those two

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