CITY SANITATION PLAN FOR DEHRADUN CITY

A DISSERTATION

Submitted in partial fulfilment of the

Requirements for the award of the degree

of

MASTER OF TECHNOLOGY

in

ENVIRONMENTAL MANAGEMENT OF RIVER AND LAKES

By

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CANDIDATE DECLARATION

I hereby declare that the work, being presented in this thesis, entitled **"CITY SANITATION PLAN FOR DEHRADUN CITY"** in partial fulfilment of the requirement for the award of the degree of **Masters of Technology in "Environment Management of River and Lakes",** submitted in **Department of Hydro and Renewable Energy, Indian Institute of Technology Roorkee** is an authentic record of my own work carried out during the period from July 2018 to Jun 2019 under the supervision of **Professor S.K. Singal, and Professor M.P. Sharma, Department of Hydro and Renewable Energy, Indian Institute of Technology Roorkee India**.

The matter embodied in this dissertation has not been submitted by me for award of any other degree or diploma.

Dated: 14/06/2019

Place: ROORKEE

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CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of our knowledge.

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Dated: 14/06/2019

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ABBREVIATION AND NOTATION

AT	Appropriate technology
ADB	Asian Development Bank
C.I.	Cast Iron
CSP	City Sanitation Plan
C&T	Collection and Transfer
DESAR	Decentralized Sanitation And Reuse
DPR	Detailed Project Report
DNN	Dehradun Nagar Nigam
ECOSAN	Ecological Sanitation
EOI	Expression of Interest
FS	Faecal Sludge
GCV	Gross Calorific Value
GOU	Government of Uttarakhand
IEC	Information, Education and Communication
ISWM	Integrated Solid Waste Management
JMP	Joint Monitoring Programme
JNNURM	Jawaharlal Nehru National Urban Renewal
KW	Kilo Watt
LPCD	Liters Per Capita Per Day
MDGS	Millennium Development Goals
MLD	Million Liters Per Day
MT	Metric tons
MW	Mega watt
NCV	Net calorific value
O&M	Operation and Maintenance
NUSP	National Urban Sanitation Policy
PHD	Public Health Department
RDF	Refuse Derived Fuel
SBM	Swachh Bharat Mission
SQM	Square Meters
SWM	Solid Waste Management

TPD	Tons Per Day
TSC	Total Sanitation Campaign
UDDT	Urine-Diverting Dry Toilet
UJS	Uttarakhand Jal Sansthan
ULBS	Local Urban Bodies
UNICEF	United Nations Children's Fund
UPJN	Uttarakhand Pey Jal Nigam
WSP	Water Safety Plans
WTE	Waste To Energy
WTP	Water Treatment Plant
WHO	World Health Organization

ABSTRACT

Urban sanitation in India faces many challenges. Nearly 60 million people in urban areas lack access to improved sanitation arrangements, and more than two-thirds of wastewater is let out untreated into the environment, polluting land and water bodies. To respond to these environmental and public health challenges, urban India needs to address the full cycle of sanitation, i.e. universal access to toilets, with safe collection, conveyance and treatment of human excreta. For a city to be fully functional it is very essential to reuse the effluents as product of our daily life. The present thesis reports the efforts made to overview and prepare city sanitation plan of Dehradun city focusing exclusively on municipal solid waste management, water supply, toilets and sewerage facilities. The work include the study of existing status of sanitation in city, identifies the major bottlenecks in implementing 100% sanitation plan and offer suggestions to improve the overall sanitation.

In this dissertation work an attempt has been made to quantifying the sanitation facilities (whether in less or surplus) in Dehradun city for both present and future populations. This dissertation is aimed at to find solutions related to sanitation problems for existing and future population. Beside this, the demand of additional infrastructure and facilities needed in future is estimated. It is done by collecting data through visits to organizations such as Pay Jal Nigam, Uttarakhand Jal Sansthan, Municipal Corporation, Solid waste plants and STP's including interview from local people. It has been observed that segregation of solid waste, negligence of waste collection workers and inadequate numbers of underground bins and transfer stations are the main issues that need to be addressed for effective solid waste management facilities in the city. As all the surface water sources have been explored, so future water demand can be fulfilled only by constructing more numbers of tube-wells and improving water distribution system.

At present there are only 21 public toilets in Dehradun city which are not sufficient for existing population, therefore more numbers of public toilets are suggested in different wards. The improvements in the area of sanitation for Dehradun city considering different parameters of sanitation are suggested such as construction of transfer station, waste to energy plant, public toilets and upgradation in capacity of water distribution system and sewerage network along with their cost estimates.

CHAPTER 1
INTRODUCTION

1.1 GENERAL

According to World Health Organization, "Sanitation is defined as the provision of the facilities and services for the safe disposal of human urine and feces". It refers to the maintenance of hygienic environment through services such as garbage collection, treatment and disposal. It is the hygienic way of promoting health through prevention of human contact with the hazardous waste as well as the treatment and disposal of sewage waste water. [1]

Sanitation is the alarming issue in developing countries and still being neglected in most of the cases. Sanitation hygiene and cleanliness are the key factors of a civilized society. Sanitation is very important for social and economic development. Increased population, increased rate of urbanization and industrialization coupled with improved life style is hindering the environment and natural resources which in turn affect human health and hygiene.

Sanitation facilities need to be enhanced in the slum areas because poor sanitation conditions leads to illness, unhygienic environment, low productivity and diseases. In the slum areas fecal waste are not handled properly which pollute water sources in the vicinity and this is the main reason for the diseases and illness of children's[2].

According to latest assessment of the WHO/UNICEF joint monitoring programme for water supply and sanitation [JMP], released in early 2013 (data collected in 2011), 36% of world's population -2.5 billion people lack well developed sanitation facilities and 768 million people still use unsafe drinking water source.[1]

1.2 NATIONAL URBAN SANITATION POLICY (NUSP)

National Urban Sanitation Policy (NUSP) refers to management of clean and safe drinking water supply and safe disposal of human excreta and associated public health and environmental impact. It is recognized that integral outcomes need to take account of other parameters of environment sanitation i.e., sewage discharge and generation, solid waste management, drainage etc.

As per the vision of NUSP "All Indian cities and town must be totally sanitized, healthy and livable to ensure good public health and environment with especial focus on hygienic and affordable sanitation services for the urban, poor and women". The overall aim of NUSP is to transform urban India into community driven totally sanitized, healthy and livable cities and

towns. According to Indian government, sanitation is a state subject and its implementation and sustenance require the involvement of urban local bodies (municipalities) and stakeholders.

1.3 OBJECTIVES OF NUSP

The overall aim of NUSP is to transform urban India into community driven totally sanitized, healthy and livable cities. The main objectives of NUSP are-

1. Awareness generation and behavior change

2. Open defecation free cities and towns

3. Integrated city-wide sanitation

4. Proper operation & maintenance (O&M) of all sanitary installations

1.4 LAUNCHING OF TOTAL SANITATION COMPAIGN (TSC)

Total Sanitation Campaign (TSC) is full-fledged rural sanitation programme and is the first of its kind. Few important elements which are added to this programme to obtain better and concrete results are: the existing total sanitation programme should include safe disposal of night soil, rain water, and domestic liquid and solid waste. It should not be limited to construction of latrines only. Awareness about the guidelines and standards of sanitation and health impact of unsanitary conditions continues to be low. Rural sanitation should be encouraged as a full package consisting of access to safe drinking water, systematic disposal of waste water, safe disposal of human excreta, solid waste management, domestic sanitation and food and personal hygiene.

1.5 NEED OF CITY SANITATION PLAN

For cities and town to be completely sanitized, livable and to sustain good public health and environment, with special focus on reasonable sanitation facilities for poor in urban areas, city sanitation plan is need. For completely safe, appropriate and urban community based cities policy sets the following goals:

1. General awareness and behavioral change.

2. Open defecation free cities and towns.

3. Integrated city wide sanitation:

4. Re-orienting institutions and mainstreaming sanitation.

5. 100% safe disposal of human excreta and liquid wastes.

1.6 CITY SANITATION PLAN

City sanitation plan is the strategic planning process for citywide sanitation sector development. City sanitation plans address both technical and non-technical aspects of sanitation services. It includes vision, missions and various goals of sanitation service development as well as strategies to meet these goals. City sanitation plans are sometime also known as municipal sanitation plans or water and sanitation strategy plans.

City sanitation plans strategies depend on the characteristics of a city. Each city is unique and requires a unique strategy to develop the city sanitation services, which should be based on a common set of principles. Sanitation services must be comprehensive and continuously accessible to every citizen. The sanitation services must suit the requirements of the entire city and all the residents should enjoy the benefits of the improved sanitation services (WSP 2010). Citywide sanitation strategy includes:

1.6.1 TECHNICAL ASPECTS OF CSP

Technical aspects of city sanitation plan include the strategy and programmes for the improvement of

- Domestic waste water services
- Solid waste management services
- Micro drainage services.

1.6.2 NON-TECHNICAL ASPECTS OF CSP

Non-technical aspects of city sanitation plan include the strategies for the improvement of non-technical aspects such as-

- Public participation and awareness
- Policies and regulations
- Institutional capacity building
- Engagement of private sectors
- Engagement of NGO's
- Financing and tariffs
- Monitoring and evaluations.

1.7 LITERATURE REVIEW

1.7.1 GENERAL

There is a great impact on the environment due to the growth of civilization, population, industrialization and subsequent need for better living standards of human being. The major environmental problems are contamination of drinking water due to discharge of household and industrial effluents without proper treatment in nearby water bodies, land pollution due to disposal of solid waste and air pollution due to release of contaminants in atmosphere. This has adverse effects on natural resources even on underground water storage and air which further affects health of living beings.

This dissertation deals with the general overview of the city sanitation plan experience and need for new low cost sustainable alternative technologies. This study also discusses the interrelationship between sanitation, waste management, ecology, environment and public health.

Various relevant research papers were studied and a brief summary of work done by different authors and their findings are tabulated below in table 1.1

Table1.1List of Literature Reviewed

AUTHOR	TITLE	WORKDONE	FINDINGS
Fewtrell et.,al(2005)	Water, sanitation, and hygiene interventions to reduce diarrhea in lesser developed countries: a review	Studied various possible interventions to reduce waterborne diseases through improvement in drinking water facility, sanitation facilities and hygiene practices in lesser developed countries.	This review concludes that individual and combined interventions of water, sanitation and hygiene practices were effective to reduce diarrheal illness, but water quality interventions (point-of-use treatment) was highly effective among all. Surprisingly, no extra benefits were noticed from the application of

			simultaneous multiple interventions.
Paterson et.,al (2007)	Pro-poor sanitation technologies	This paper summarizes low-cost sanitation technologies that have been developed by engineers from around the world, and seeks to provide evidence that there is such a things as a pro-poor technology.	Concluded that if there is a lack of investment in sanitation and insufficient cost recovery than simplified sewerage system is preferred over the innovative low cost technologies.
Murphy et.,al (2009)	Appropriate technology–A comprehensive approach for water and sanitation in the developing world.	Studied the appropriate technologies for water and sanitation and he conclude that Traditional engineering approaches needs to be augmented with more flexible trial and error techniques.	Use of locally available materials makes the technique more economic. There is no blueprint solution which is suitable for every circumstance. Collaborative and multidisciplinary approach is needed to develop and implement the appropriate sanitation technologies.
Shekdar, A. V. (2009)	Sustainable solid waste management: an integrated approach for Asian countries.	This paper contains analysis of present system of SWM in different Asian countries, and explores future trends. Author has conceptually evaluated issues surrounding the	Proposed an way to attain sustainable SWM in context of national policies and legal frameworks, monetary and operational management, institutional arrangement, appropriate

		sustainability of SWM.	technology and public awareness and participation. It would be best to develop sustainable solid waste management rather solid waste management for sustainable society.
Katukiza et.,al (2010)	Selection of sustainable sanitation technologies for urban slums—A case of Bwaise III in Kampala.	This paper provides a unique technology selection method for the selection of an appropriate solution for urban slums sanitation problems.	Point out that, to select appropriate sanitation approach for the urban slums we must consider sustainability criteria, social acceptance, technical and physical aspects, institutional and technical aspects and need to improve and protect human health and environment.
Katukiza et.,al(2012)	Sustainable sanitation technology options for urban slums.	This paper reviews the characteristics of waste streams and the potential treatment methods and technologies which can be adopted in urban slums in a sustainable way. Technologies that promote resource recovery using on-site	Typically very high cost sewer systems and dependency on the presence of running water can be avoided, thus DeSaR and EcoSan based technologies are considered to be accessible to the poor and fit in a system contributing to the MDG's

		sanitation systems are applied within the concepts of ecological sanitation (EcoSan) and decentralized sanitation and reuse (DeSaR).	. UDDT is a suitable low cost sanitation technology for urban slums
Ghosh & Cumming (2013)	Open defecation and childhood stunting in India: an ecological analysis of new data from 112 districts.	Conducted an ecological regression analysis to find the interdependency between open defecation and child stunting.	Open defecation is an important cause of child stunting in India female literacy is another factor which affect child stunting.
Guerrero et.,al (2013)	Solid waste management challenges for cities in developing countries.	The objective of this study was to determine the stakeholders' actions or behavior that have a task within the waste management method and to investigate prestigious factors on the system, in more than thirty urban areas in 22 developing countries in four continents.	SWM involves a large numbers of stakeholders, with different interests, but often it is seen only as a responsibility of the local authorities. SWM is a multi-dimensional issue. Effective system isn't solely primarily based on technological solutions however additionally on environmental, socio-cultural and legal.
Lohri et,.al (2014)	Financial sustainability in municipal solid waste management– Costs and revenues in Bahir Dar, Ethiopia.	This paper presents a cost-revenue analysis, based on data from July 2009 to June 2011 to know that is a private company able to generate sufficient revenues from their activities to offset	The results of the research therefore shows that a more detailed cost structure and cost-revenue analysis of this waste management service is important with appropriate measures,

		the prices and generate some revenue.	either by the privates sector itself or with the support of the local authorities, in order to enhance cost efficiency and balance the cost-revenues towards cost recovery.
Dr. MinakshiP .Hazarika, (2015)	Sanitation and its impact on health: A Study in Jorhat, Assam.	In this paper, an attempt is being made to assess the status of sanitation and its impact on the health of the people in Jorhat Assam.	It is seen that 80% pollution in Indian rivers is due to excreta and the impact of this on public health is catastrophic. Poor quality drinking water and sanitation is the second largest killer in India, malnutrition being the first.
Augsburg & Rodriguez-Lesmes (2015)	Sanitation and child health in India	Examine the effects of sanitation coverage and usage on child height for age in a semi-urban setting in Northern India.	Child stunting is a major hindrance to human capital development. High population density and lack of adequate sanitation facilities provide a breeding ground for preventable disease epidemics. Two major factors to reduce stunting are; a) open defecation free communities & b) female literacy.

Gupta et.,al (2015)	A review on current status of municipal solid waste management in India.	An overview of current status of solid waste management in India which can help the competent authorities responsible for municipal SWM and researchers to prepare more efficient plans.	The continuous indiscriminate disposal of domestic solid waste is growing fast and is coupled to poor financial conditions, poor governance, rapid urbanization, population growth, poor living standards, low level of environmental awareness and inadequate management of environment.
Hu Ming et.,al (2016)	Constructing the ecological sanitation: a review on technology and methods.	The review comprehensively summarized the main components of the Eco-San system (user interface, collection and conveyance, storage and primary treatment, and reuse/disposal), the frequently-used evaluation methods, and the framework of evaluation index system.	The result shows that the Eco-San systems are beneficial for resource efficiency, agricultural use of the organic matters and nutrients, and energy recovery although some shortages exist (e.g. high input cost, some cultural constraints, and complex operation method and management).
Singh et.,al (2017)	Technology options for faecal sludge management in developing countries: Benefits and revenue from	This article provides technology options for the treatment of Faecal Sludge (FS) in developing countries to minimise exposure to FS	An appropriate and economically sound technology is needed to achieve proper FS disposal with potential recovery of valuable

	reuse.	and assesses its benefits along with possible revenue generation from reuse.	constituents from sludge.
Afolabi et.,al(2017)	Microwaving human faecal sludge as a viable sanitation technology option for treatment and value recovery	This review intends to advance the understanding of human faecal sludge as a sustainable organic-rich resource that is typically high in moisture, making it a suitable candidate for dielectric heating, i.e. microwave irradiation, to promote faecal treatment, while also recovering value-added products.	Discussed about faecal sludge management options in developing countries, review stated that an appropriate and economically sound technology is needed to achieve proper FS disposal with potential recovery of valuable constituents from sludge.
Gwenzi et.,al (2017)	Biochar-based water treatment systems as a potential low-cost and sustainable technology for clean water provision.	Works on conversion of bio-waste into biochar through pyrolysis which could be coupled to household energy and food provision. The capacity of biochar to remove multiple chemical and microbiological contaminants in aqueous systems has also been demonstrated.	Proposes a new water treatment technique which is based on Biochar, which have an excellent property to remove impurities from aqueous solutions. they claimed several advantage of Biochar technique over other known low cost methods (i.e., sand filtration, boiling, solar disinfection, chlorination)

1.8 JUSTIFICATION FOR SELECTING DEHRADUN CITY FOR CSP

Dehradun city is chosen as a study area for the dissertation because of the following reasons

1. Dehradun, the capital city of Uttarakhand is a famous educational hub of north India where people are migrating from different states.
2. City is a tourism attraction point as it is in vicinity of hill station Mussoorie and yoga capital of the world Rishikesh.
3. In the recent decades, there is sudden jump in population thus increasing no of residents and commercial buildings, educational buildings and hospitals, thus city need a planning process for sanitation services.
4. Under Swachh Bharat mission, Dehradun city got 384th rank out of 450 cities having population more than one lakh in Swachh Survekshan 2019, which was 259th in last year's ranking. The city scored only 1342 out of 5000 in Swachh Survekshan 2019. This ranking indicates the requirement of planning for improvement in sanitation services in city.

1.9 GAPS IDENTIFIED

1. Lack of literature for potential recovery of valuable constituents from sludge.
2. Lack of study on waste utilization and recycling.
3. Lack of study on demand and supply related problems for water supply in cities which is major cause for unequal distribution of water.
4. Low tariff collection efficiency for MSW in Dehradun city.
5. There is no study on encroachment on Rishpana and Bindal River till now, which these days have turned into big drains.
6. Open dumping is another problem which should be changed to sanitary landfilling.

1.10 OBJECTIVES OF DISSERTATION

1. To identify the various point and non-point sources of pollution in Dehradun city.
2. To adopt a demand based strategy and community participation in planning, implementation and management of sanitation infrastructures in the city.
3. To make Dehradun city open defecation free and eliminate all environment hazards in all urban space like commercial areas, offices and institutions.
4. To plan a complete waste management cycle (collection, conveyance and treatment) of solid waste.
5. To improve existing sanitation facilities and related O & M management system.

6. To estimate cost for improvements proposed in sanitation services.
7. To adopt suitable methods, technology and materials which are locally available and provide necessary support to local urban bodies.
8. To encourage public and private partnership and define their roles in improvement and maintenance of sanitation services in Dehradun city and thereby ensure a sense of ownership.

1.11 METHODOLOGY

To achieve above mentioned objective following methodology is adopted:

1. Inspection of site-Dehradun city was done for understanding the existing condition of sanitation services in city.
2. Secondary data for different parameters of sanitation such as solid waste, water supply, toilets and sewage was collected from the respective authorities.
3. The population data was forecasted till the year 2041 using arithmetic mean method.
4. The collected data was analyzed for demand, supply and the shortage in the supply was calculated.
5. The existing condition of SWM system, sewerage system and water supply was assessed by data analysis and extensive site visits.
6. New proposals for improvement in SWM, sewerage system and water supply is proposed.
7. Cost estimation is done for proposed improvements.

CHAPTER 2
SELECTION OF DEHRADUN CITY FOR CSP

2.1 ABOUT DEHRAUN CITY

Dehradun is the capital city of Uttarakhand state and one of main administrative center of north India. Dehradun city is well known for its natural beauty and its pleasant climatic condition throughout the year. That is why Dehradun is one of the best residential cities in the country.

The city is one of the best resort centers in the north India; it is recognized for its charming natural beauty, beautiful forest cover, waterfalls and climate. It is an important educational center of the country. Various offices of center and state government such as Regional Science Center, Indian Military Academy, Survey of India, ONGC and many other are situated here.

Dehradun city is well connected with country and other states with air routes, railway lines and roadways. Hindi, Garhwali, Kumauni and Punjabi are the main language which is mainly spoken in the city.

2.1.1 TOPOGRAHY AND NATURAL RESOURCES

Dehradun is surrounded by Himalaya range in north and Shivalik range in its south, Ganga River is flowing in its east and river Yamuna to the west side. The Doon valley is located between two holly Rivers i.e. Ganga and Yamuna. Dehradun city is surrounded by beautiful dense forest in its all directions and lots of streams and canals is flowing in the city from north to south direction. All the hills which surround the Dehradun city are rich in lime stone reserves. The location of Dehradun city and its ward map is shown in fig 2.1 and 2.2 respectively.

The population change in 1980's and 1990's decades was 21.32% and 21.85% respectively but in next decade there was a sudden jump in population about 39.70% because in 2000 Uttaranchal is formed as separate state with Dehradun as its capital. In 1991-2001 population growth rate grows up to 39.70% which was due to its formation, economic growth and expansion of industries in state.

Dehradun is developed as a good education center, industrial hub, best infrastructure in the state and institutional development with the help of financial assistance of the ADP and overall the city developed under Jawaharlal Nehru National Urban Renewal Mission (JNNURM) which opened employment opportunities both in secondary and tertiary sectors.

2.1.2 HISTORICAL BACKGROUND

History of the city goes back to 17th century. It is occupied by the British government in 1815 and always been there one of the favorite place due to its pleasant climate and location.

During the Rai period, Dehradun city become an important academic and research center and station for Indian Military Academy and the survey of India. There are various reputed boarding schools including Doon school, which is one of the best private schools in India.

Two military cantonments were established in Dehradun in 1872 and 1908, which further accelerated the overall growth and development of the city. The establishment of tea industry near Premnagar, growth of city as cantonment and formation of hill city Chakrata, increasing population of hilly city Mussoorie and formation of railway line in 1900 have all contributed toward overall development of city and great progress in material prosperity and growth of Dehradun. After the independence of the country, growth of the city accelerated with its population as well as area. Establishment of large industries and banks triggered the growth of Dehradun.

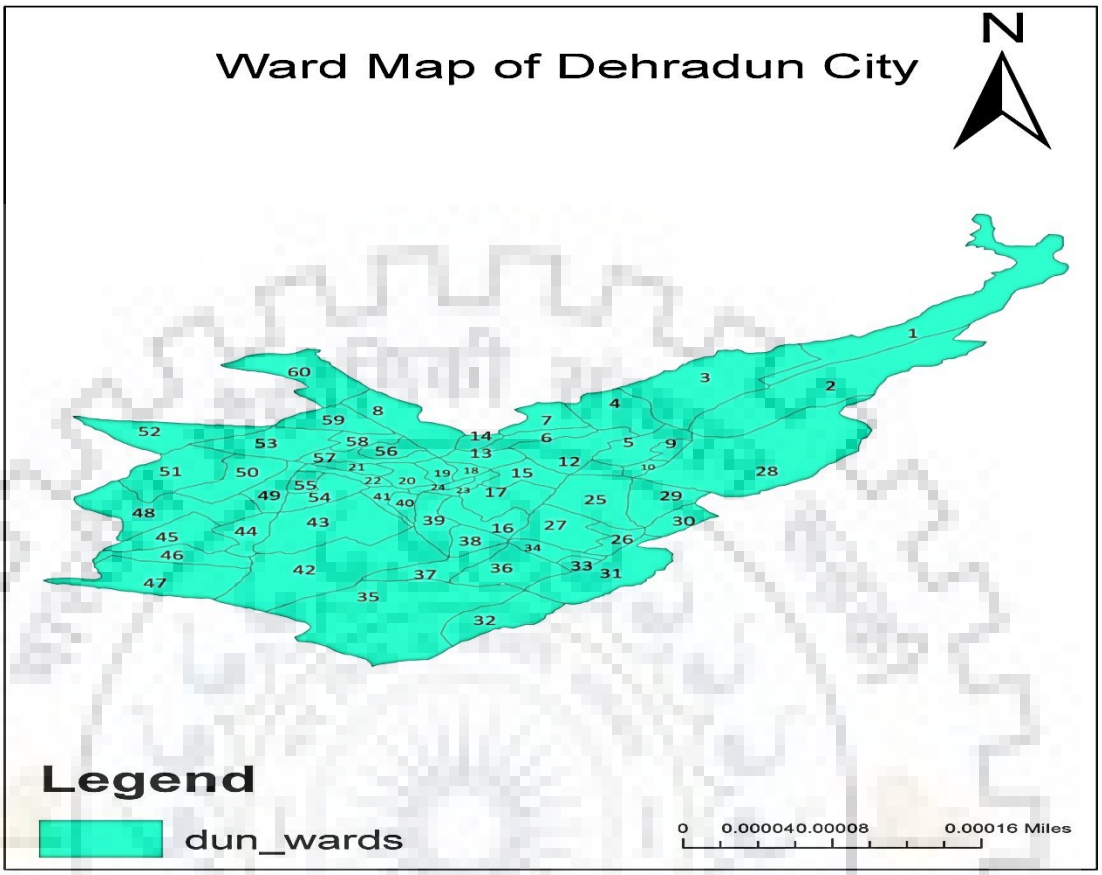


Fig.2.2 Dehradun ward map

2.1.3 CLIMATE

Dehradun city is at 2,200 feet above the sea level. The climate of Dehradun city is very pleasant because of the hilly area around it. Even in summers the average temperature is around 30 to 35 degree Celsius. In winter, the temperate varies from 23 degree to 5 degree. During June to August, city experience heavy to moderate shower. Most of the annual rainfall of about 2000 mm in Dehradun district is recorded during June to September months whereas July and August experience the heavy rainfall. As a whole, climate of Dehradun city is neither too cold nor too hot.

2.1.4 CITY AND ITS SURROUNDING

Dehradun city has several attractions, most of them are tourist attraction points, academic institutions and research oriented centers of national and state importance. City is surrounded with Queen of Hills Mussoorie, Yoga capital of the World and hill area Chakrata.

2.1.5 INSTUTIOANL ATTRACTIONS

Many prestigious institutions of national importance like Indian Military Academy, Forest Research Institute, Indian Institute of Petroleum, Oil and Natural Gas Commission, Indian Institute of Remote Sensing, Wadia Institute of Himalayan Geology, Survey of India and National Institute of Visually Handicapped etc. are located in Dehradun city.

2.1.6 TOURIST ATTRACTION

Dehradun, the capital city of Uttarakhand state is visited by very large number of visitors every year, many of them enroute to Rishikesh, Chakrata and Mussoorie. There are lot of places in Dehradun and its surroundings which are worth visiting some of them are Shahastradhara, Dehradun Zoo, Dakpatthar Barrage, Ponta Saheb, Robbers Cave, Tapkeshwar Mandir, Raipur Spring, Shiv Mandir etc. there is a famous archeological site known as Kalsi which is situated near Yamuna River on the route from Dehradun city to Chakrata.

Famous Tiger reserve and Indian National Park, Rajaji National Park is located at edge of Dehradun valley, which was established in 1966 and covering over about 820 sq. km area. Rajaji National Park is situated in the luxurious valley of Shivalik Range; it is an ideal destination point for tourists, a famous picnic spot and expedition site for nature lovers.

2.2 SOLID WASTE MANAGEMENT

Solid Waste Management needs to manage the solid waste from source to its final disposal point and includes the collection, transportation, treatment and disposal of solid waste together with monitoring and regulation of the waste management process. To study the general sanitation status based on MSW management, the following data are collected.

2.2.1 POPULATION DATA

As per the population census 2011, the total population of Dehradun is 574,840 out of which 301,207 are males and 273,633 are females thus the average sex ratio of Dehradun is 908. Population is projected till 2041 using arithmetic increase method and tabulated below in table 2.1 and trend in population growth is shown in fig 2.3.

Table2.1 Population Forecasting For Municipal Corporation

S.No.	YEAR	POPULATION
1	1991	270159
2	2001	426674
3	2011	574840
4	2021	727180
5	2031	879521
6	2041	1031861

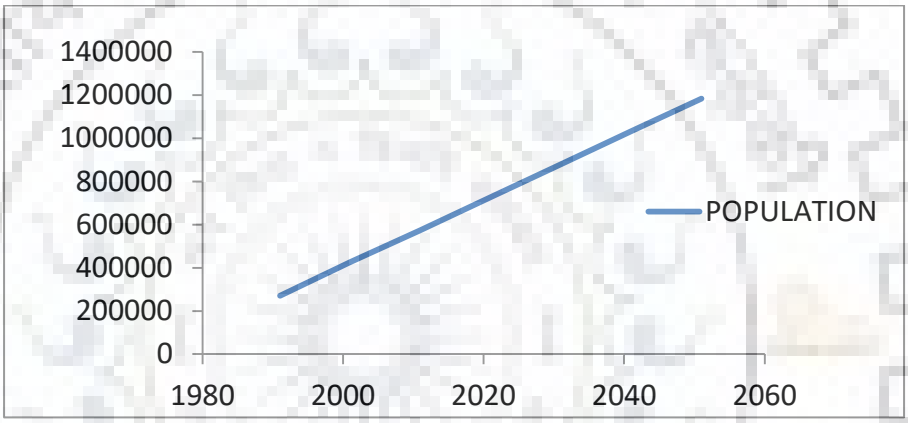


Fig.2.3 Population Projection

Population data indicate a constant growth in population which was highest in 1991 to 2001 due to formation of Dehradun as a capital of Uttarakhand state, at present the growth rate is still very much.

2.2.2 MSW GENERATION AND ITS PROJECTION

According to the "Dehradun Nagar Nigam (DNN)" the city on an average generates about 250 MT of MSW per day at present. The assessment is based on the assumption of per capita generation @ 0.4kg/capita/day. At present MSW treatment plant at Shishambada is processing about 250 MT per day though its capacity is 400 MT. By comparing present treatment facility of MSW gaps (Shortage/Surpluses) in MSW treatment services are calculated as shown in table 2.2.

Table2. 2 Shortage/Surpluses in SWM Services

S.No.	YEAR	POPULATION	WASTE GENERATION (MT) PER DAY @ 0.4kg/capita/day	PRESENT SOLID WASTE TREATMENT PER DAY(MT)	GAP IN SERVICE (MT)
1.	2011	574840	229	250	21
2.	2021	727180	290	250	-40
3.	2031	879521	352	250	-102
4.	2041	1031861	413	250	-163

As per the calculations at present the waste treatment facility is sufficient but from 2021 onwards existing solid waste treatment facility in Dehradun will not be sufficient, we will need a plant with treatment capacity of 413 MT/day till 2041.

2.2.3 COLLECTION, STORAGE AND TRANSPORTATION OF MSW

Existing collection system mainly comprises of:

- Door to door collection by private agencies
- Collection from streets by means of hand crafts/cycle-rickshaw and
- Collection through community bins/containers.

1. HUMAN RESOURCES EMPLOYED FOR SW COLLECTION

Municipal Corporation sweepers and sanitary workers engaged by the Mohalla Swachhata Samities sweep solid wastes from the streets. They accumulate the collected waste into small heaps and subsequently loaded manually or mechanically on to the solid waste transportation vehicles for onward transportation to the disposal site. This refuse is then transferred to big dumper and carried for processing to Shishambada Plant. Table 2.3 shows resources employed for waste collection in the city.

Table2.3 Resources Employed For Solid Waste Collection

S.No.	Resource Employed	Total Number	Duties
1	Permanent Employees	754	collect waste from roads, streets, and drains and place it to the nearby dustbins
2	Contract Employees	05	
3	Swachhata Samitie Worker	610	
4	Seasonal Workers	120	clean the drain
5	Automated Cleaners	75	clean the drain during night

Source: Dehradun Municipal Corporation (2018)

To monitor the cleaning arrangements one head cleaner is deputed to every ward and therefore there are 60 City cleaners to be monitored by 9 sanitary supervisor and 1 senior city health officer and Assistant city officer.

2. UNDERGROUND BINS IN CITY

All the underground bins located in city are listed below with their locations, capacity, total numbers, operational status and operation and maintenance status in table 2.4 below. Fig 2.4 shows the location of underground bins in Dehradun City.

Table2.4 Status of Underground Bins Project Dehradun

S.No.	Location	Capacity			Total	Status	O&M Status
		3cu.m	2.5cu.m	1.5cu.m			
1	Nehru Colony Near LIC	3	0	0	3	Installed	Daily
2	Dharampur Mandi	0	3	1	4	Installed	Daily
3	Rajeev Nagar near bridge	2	1	0	3	Installed	Daily
4	MDDA colony ISBT L1	0	1	0	1	Installed	Daily
5	MDDA colony ISBT L2	0	1	0	1	Installed	Daily
6	Canal road L1	0	2	0	2	Installed	Daily
7	Canal road Dhoran bridge	0	2	0	2	Installed	Daily
8	Indranagar near Jalagam	1	0	3	1	Installed	Daily
9	Yamuna colony D lane	0	1	1	2	Installed	Daily
10	Yamuna colony Govindgarh gate	0	2	0	2	Installed	Daily

11	Yamuna colony E block	0	0	2	2	Installed	Daily
12	Madrasi colony	0	0	4	4	Installed	Daily
13	Defence colony	0	1	2	3	Installed	Daily
14	Nari niketan	3	0	0	3	Installed	Daily
15	Sachiwalaya colony	0	3	1	4	Installed	Daily
16	Deep nagar	2	0	1	3	Installed	Daily
17	Opp. Roadways workshop	0	2	3	5	Installed	Daily
18	Tarala Adhoiwala	3	0	0	3	Installed	Daily
19	Tibbati market	0	0	3	3	Installed	Daily
20	Balbeer road	0	0	4	4	Installed	Daily
21	Shanti vihar Govindgarh	2	0	1	3	Installed	Daily
22	Yamuna colony DT block	0	0	2	2	Installed	Daily
23	Nalapani chowk	0	0	3	3	Installed	Daily
24	Officers colony dharampur	0	0	2	2	Installed	Daily
25	Lalpul	2	0	1	3	Installed	Daily
26	Majara	0	0	3	3	Installed	Daily
27	Kolagarh road(FRI external)	0	1	3	4	Installed	Daily
28	Chaman puri	2	0	0	2	Installed	Daily
	Total	20	20	40	80	Installed	Daily

Fig.2.4 Dehradun ward map showing existing underground bin

3. WASTE COLLECTING MACHINES AND VEHICLES

Dehradun Nagar Nigam presently utilizes the following vehicles and equipment for Transportation of solid waste as given in table 2.5.

Table2.5 Equipment Used to Transport Solid Wastes

S.No.	Type Of Vehicles	Total Numbers
1	Cycle Rickshaw's	82
2	Tata Ace/Hooper	77
3	Refuse Compactor	02
4	HYVA Vehicle	02
5	Dumper Truck	10
6	tractor Trolley	10
7	JCB	06
8	Loader	04
9	Private Tractor Trolley	08

Source: Dehradun Municipal Corporation (2018)

These vehicles collect solid waste to nearby underground bins which are present in different locations in cities.

2.2.4 MSW TREATMENT IN DEHRADUN

According to cities MSW management scheme in-liu-of technique of scientific trench filling, 240 MT of waste is disposed-off every day. To take care of the above agreement were signed on 23rd Jan 2018 with Dehradun Waste Management Pvt. Ltd. (A Ramky Group Venture) to carry out the composting work on regular basis. A treatment plant (composting based) is set up as per details given below.

1. Shishambada Plant

The total area of this plant is about 8.323 hectares. It is India's first fully covered, aerobic composting SWM processing facility, fitted with 28 waste dumping chambers. Currently, the plant is processing 250MT of waste daily. The total capacity of plant is 400 MT per day. Technical details of Project are shown in table 2.6. Fig 2.5 shows the fully covered aerobic MSW management plant in Dehradun.

Project Features

Fig.2.5 Shishambada MSWM plant

Table2.6 Main Features of Shishambada Project

Particulars	Details
Proposed Area	8.323 Hectares or 83230 square meter.
Proposed Capacity	150 MT/day capacity of compost plant
Total population to be served	7.8 Lakh
Landscape/Green belt development area	20% of plot area i.e.1.664 Hectares(16640 square meter) Green belt will be 15 meter wide
Total waste generation	257 MT/day
Power demand	150 KVA (Uttarakhand Electricity Board)
Expected Cost of Project(SLF & Composting)	Rs 1083.24 Lakhs
Project duration	1 year

Source: Dehradun Municipal Corporation (2018)

2. Segregation of MSW

SWM plant Shishambara is located at about 20 km from Dehradun city. The total area of this plant is about 8.323 hectares. It is India's first fully covered, aerobic composting SWM processing facility, fitted with 28 waste dumping chambers. Currently, the plant is processing 250MT (2.5 Lakh Kg) of waste daily; the total capacity of plant is 400 MT (4 Lakh Kg) per day.

Waste processing flow chart is shown below. Waste is collected from city by municipal trucks and these trucks carried the waste to this plant for processing.

It all starts with trucks driving in with waste not segregated, collected from residences and commercial interests. Waste is weighted and recorded at the record room near main gate entrance. After that this non segregated waste is unloaded at tipping floor. This large size non segregated waste is processed through 75 mm trommel which segregates waste of size greater than 75mm. this segregated waste is collected and dumped at sanitary landfill. And the finer waste from 75 mm trommel is carried to mechanized aerobic windrows for fermentation. The waste is left idle for the next 28 days, and is treated with a "culture" mix of cow dung and urea. Air is pushed into the dump piles from an underground piping facility to enable a faster aerobic decomposition. This results in natural composing of wet waste; the waste reduces in size and the foul smell is also reduced. This pile is then collected and passed through 25 mm and 4 mm trommel, which separate larger non bio-degradable(such as plastic, cloths and wood) from finer compost. The entire 28 chamber (mechanized aerobic windrows) are connected with pipes below the surface to drain the leachate collected during fermentation of waste for 28 days, this leachate is pumped to 2 leachate treatment ponds where this leachate is treated to desired quality of water. The treatment of leachate is solar powered, making it an environment-friendly process. To prevent the pollution of groundwater due to generation of leachate, the landfill is fitted with geo-synthetic clay liner sheets (imported from Italy), which will block the penetration of moisture or water into the ground.

Fig 2.6 shows the flow diagram of the processes involved in the treatment of solid waste Plant.

The end results of this process are:

- Compost: Out of a total 250MT of waste, 25MT of compost is generated.
- Sanitary Landfill: Almost 50MT of waste goes to sanitary landfill. This waste can't be used further.

- Refused Derived Fuel: The remaining part of waste is converted into RDF and can be used for combustion purpose in big machines, power plants and cement factories. As of now they are just colleting the RDF for thermal power plant going to be start near the site location.

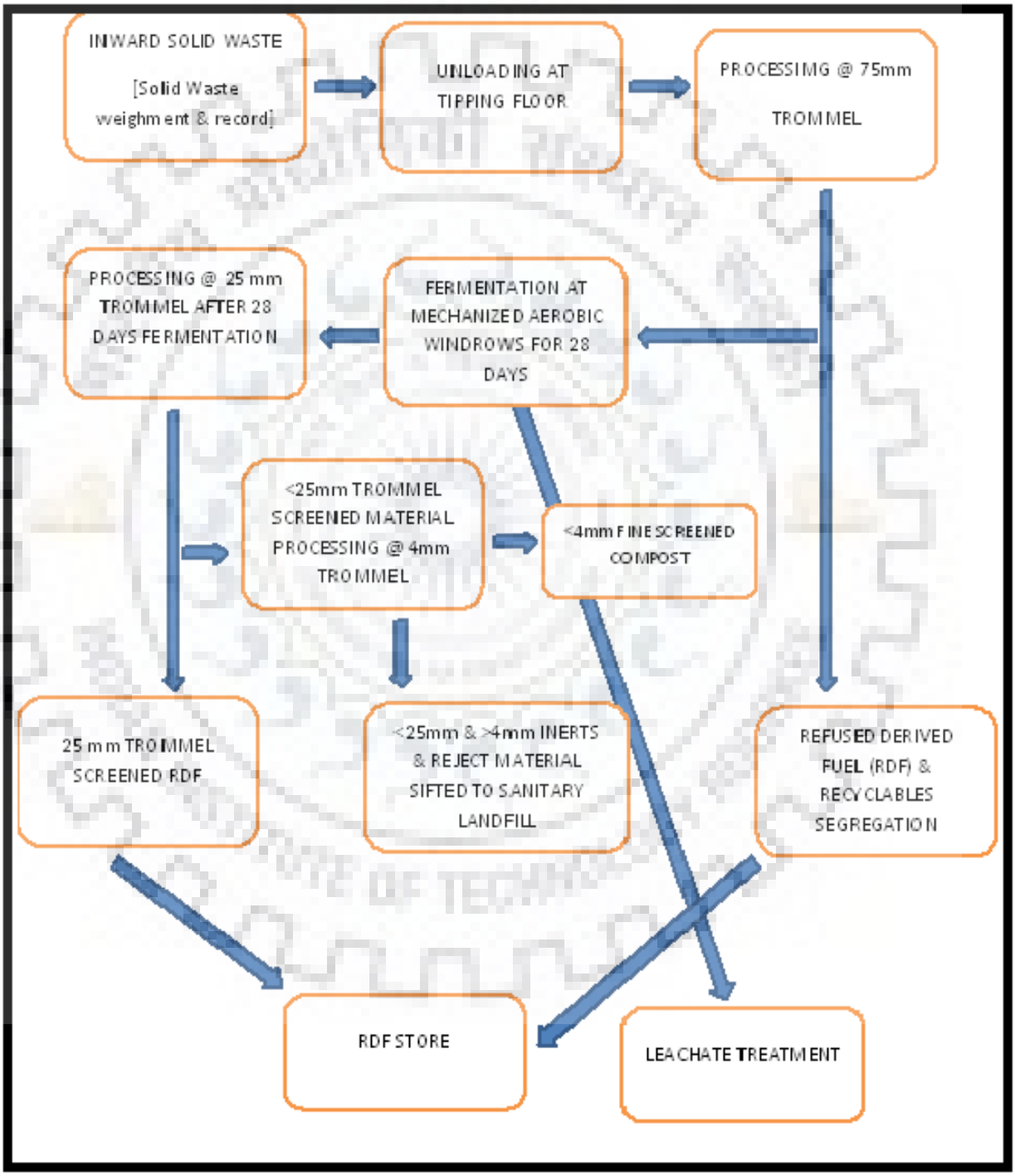
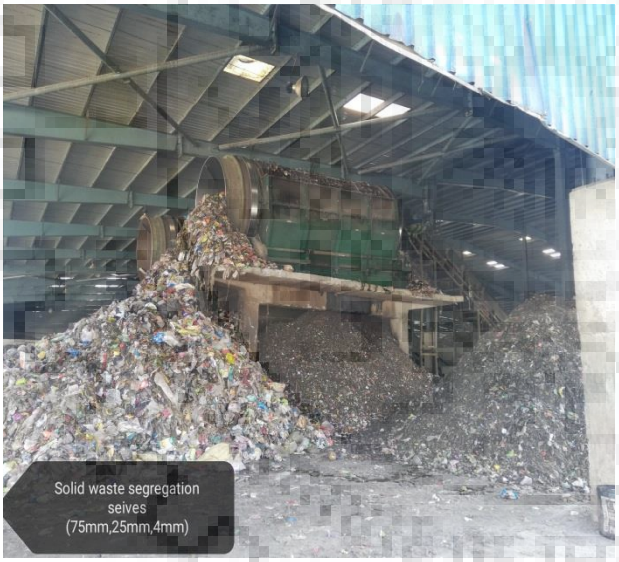


Fig.2.6 Complete Treatment Process in MSW Treatment Plant

3. Landfill Specifications

Landfill sites are the areas where solid waste is dumped or disposed for its treatment. It is the conventional method of garbage dumping. These days landfill sites are designed such as it will not pollute our groundwater sources of water and nearby soil also.

The main objectives of the plant operator i.e. Dehradun Waste Management Pvt. Ltd. (A Ramky Group Venture) is to reduce the dumping of garbage on landfill from current the 25% of the total garbage to 10% in the coming ten years. To prevent the pollution of groundwater due to generation of leachate, the landfill is fitted with geo-synthetic clay liner sheets (imported from Italy), which will block the penetration of moisture or water into the ground. The treatment of leachate is solar powered, making it an environment-friendly process. Fig 2.7(a) to 2.7(d) shows the different processing units in the solid waste management plant in Dehradun.



(a)

Segregation Trommel(75mm) at SWM Plant

(b)

Waste Processing Chambers

(c) (d)

Leachate treatment pond 1 Leachate treatment pond 2

Fig.2.7 Different processing units in the solid waste management plant in Dehradun

2.2.5 SAMPLE COLLECTION AND ANALYSIS

1. Analysis of compost samples [20]

SWM plant at Shishambara was visited and samples of Compost collected from the plant were analyzed for its manurial characteristics and the results are compared with the standards of City Compost provided in the Manual for Bio fertilizers and Organic Fertilizers in Fertilizer (Control) Order, 1985 as given in table 2.7.

Table2.7 Average Chemical Composition of Compost

Parameters	Average value	Standards
pH	7.2	6.5-7.5
Moisture Content(% dry basis)	23.6	15-25
Total Organic Matter(% dry basis)	27.57	>20
Nitrogen content(% dry basis)	0.82	>0.80
Total Organic Carbon(% dry basis)	15.99	>12
C/N ratio (% dry basis)	19.5	<20

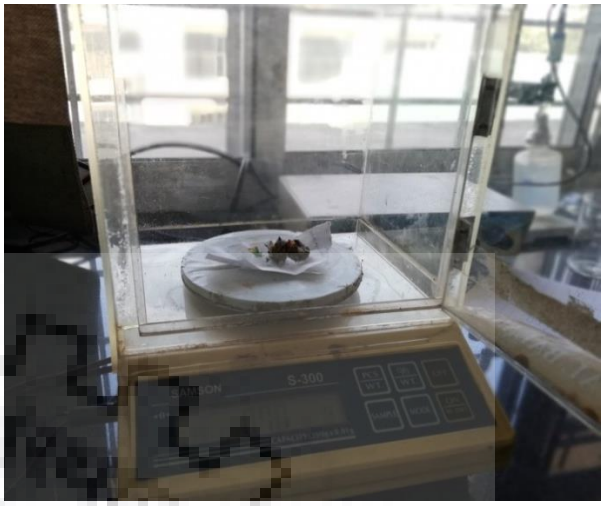
The advantages of city compost are:

- Plants are able to absorb only 20% to 50% of nutrients from synthetic fertilizers, rest of nutrients runs down in ground water, rivers and lakes which pollute these water sources. but organic compost acts like a sponge it hold up nutrients for a longer period till all the nutrients get absorbed by plants. Thus use of city compost contributes to quality of water in water bodies.
- Use of city compost benefits the environment by recycling the organic solid waste of city as well as minimizes the land requirement of sanitary landfill.
- Chemical fertilizer provide nutrients within 1 or 2 days but organic fertilizer provide nutrients for long period which make is suitable for long duration crops such as sugarcane.
- Compost is good for soil quality it helps to grow plants healthy with strong root system. It increases the natural resistance for pest and decay. Plants grown with compost needs lesser amount of pesticides thus save input cost with less environment pollution.
- Use of compost increase soil water holding capacity, aeration and cation exchange capacity of soil.
- Compost can Control many soil borne diseases.

(a) Weighing compost sample for testing

(b) Compost samples

(c) Weighing compost samples after owen drying



(d) Weighing prepared RDF sample for calorific value test

(e) Increased temperature reading in bomb calorimeter

(f) Calorific value test

Fig.2.8 Experiments performed on compost and RDF samples.

Fig 2.8 (a) to 2.8 (f) shows the photos related to compost and RDF samples analysis.

2. Refused Derived Fuel (RDF)

RDF is fuel obtained from various wastes generated from household, industries and other sources, which have combustible properties. As new sources of energy generation are urgent need of era, RDF is a potential source of clean/green energy and an effective way of waste disposal on the

other hand. Waste gasification is the latest technology to convert solid waste material to green energy [29].

RDF samples were collected from SWM plant Dehradun and calorific value and moisture content are calculated using standard procedures and the results are presented in table 2.8.

Table2.8 Results for RDF

Parameter	Average Value Obtained
Moisture content(% dry basis)	36
Gross Calorific Value(Kcal/kg)	3200

Calorific value of RDF is found out to be 3200 kcal/kg, which is quit high, although it can vary between 2500 to 3500 kcal/kg. It means this RDF is suitable for energy generation and has a high energy potential.

2.3 TOILETS

Toilets are the basic requirement for people but generally considered for granted by those which have a regular access. Insufficient public toilets or community toilets are the indication to inadequate sanitation system in urban India. Generally citizens, particularly in market places such as railway stations, bus stations, city malls etc. do not find public toilet when they need. This part of thesis includes the study of public and community toilets in the city.

2.3.1 PUBLIC TOILETS

Public toilets are those toilets which are provided for floating population or general public which are out of their houses such as in market place, railway stations, and bus stations, near commercial buildings or other public areas where a large number of people gather daily.

Under Swachh Bharat Mission (urban), all the states and ULBs have to ensure that sufficient number of toilets should be constructed in every city. Every important place in the city which is public attraction points must be covered. SBM suggest that 1 seat should be available for every 100 users near big shopping stores and commercial areas in the cities [24]. List of public toilets in Dehradun city based on information obtained from Nagar Nigam Dehradun in table 2.9.

Table2.9 List of public toilets in Dehradun

S.No.	Ward No.	Location	Male	Female	Urinals	Total Seat	Landmark	Type Of Monetization
1	3	Jakhan	4	4	-	8	Dila Ram Chowk	Private
2	4	New Cantt Road	2	1	-	3	Survey Gate	Private
3	4	Salawala	5	5	1	10	Salawala Chowk	Private
4	60	Kaulaghar Road	3	3	2	6	KedriyaVidhyalaya	Private
5	56	Bindal Road	2	2	2	6	BindalPul	Private
6	13	ChukhuMohalla	5	5	3	10	ChukhuMohalla	Private
7	15	Parade Ground	9	5	2	14	Opposite BJP Office	Private
8	15	Clock Tower	7	3	-	10	Near GPO	Private
9	15	Gandhi Park	9	3	-	12	Gandhi Park	Private
10	17	Nagar Nigam Campus	5	5	1	10	Nagar Nigam Campus	Private
11	17	DM Office	7	4	2	11	Kachari Road	Private
12	17	DM Office	4	3	5	7	Kachari Road	Private
13	17	KachariParisar	3	2	1	5	Kachari Road	Private
14	17	ChappanBhog	2	2	-	4	Kachari Office	Private
15	25	Gandhi BastiChandar Road	3	4	1	7	Gandhi Basti	Private
16	26	NayiBastiBalveer Road	4	4	-	8	NayiBasti	Private
17	31	Rajeev Nagar	3	2	2	5	Tracker Stand Rispana Pull	Private
18	41	Lakhi Bag Road	5	5	-	10	Lakhi Bag Police Station	Private
19	43	Mata Wala Bagh	5	5	1	10	Mata Wala Bagh	Private

20	45	NiranjanPurMandi	10	5	2	15	Mandi	Private
21	47	ISBT	5	2	-	7	ISBT	Private

Source: Nagar Nigam Dehradun (2018)

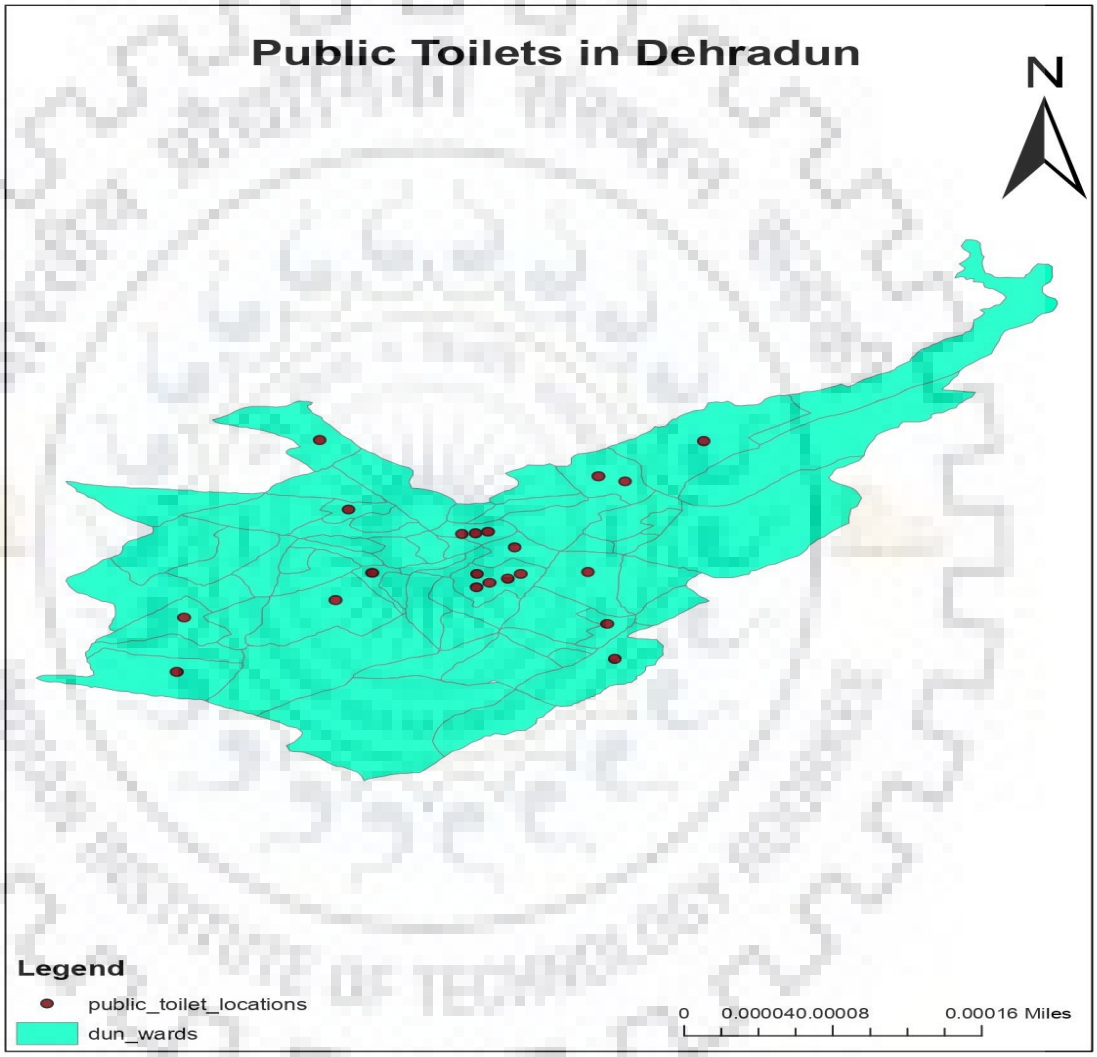


Fig.2.9 Existing Public Toilets in Dehradun

Only 21 public toilets are available in city which cannot fulfil requirement for such a large population, more no of public toilets are proposed at other important areas of tourist attraction, market places and public parks in chapter 4. Fig 2.9 shows the locations of the existing public toilets in Dehradun city.

2.3.2 COMMUNITY TOILETS

Community toilets are those toilets which are provided for an entire community or group of families, it is a shared facility provided by municipalities. Generally community toilets are provided for low income groups or informal settlements or urban slums which have low income and lack of space. These types of toilets are generally for groups which live at a fixed place. List of existing community toilets is given below in table 2.10.

Table2.10 List of Community Toilets in Dehradun

S.No	Ward No.	Location	Male	Female	Urinals	Ph	Total Seat	Type Of Monitization
1	1	Main Rajpur	-	-	2	-	2	Nagar Nigam
2	8	SayadMohalla	3	3	4	2	8	Nagar Nigam
3	28	NayiBastiNalaPani Road	5	5	-	-	10	Nagar Nigam
4	10	Valmiki Basti	5	5	-	-	10	Nagar Nigam
5	10	KhatikMohalla	5	5	-	-	10	Private
6	18	LuniyaMohalla	5	5	-	-	10	Private
7	19	DandiPur	6	5	-	-	11	Private
8	25	Dalanwala	5	5	1	-	10	Private
9	26	NayaGaon	2	3	-	-	5	Private
10	42	Single Mandi	5	5	-	-	10	Private
11	43	Patel Nagar Tapri	5	5	-	-	10	Private

Source: Nagar Nigam Dehradun (2018)

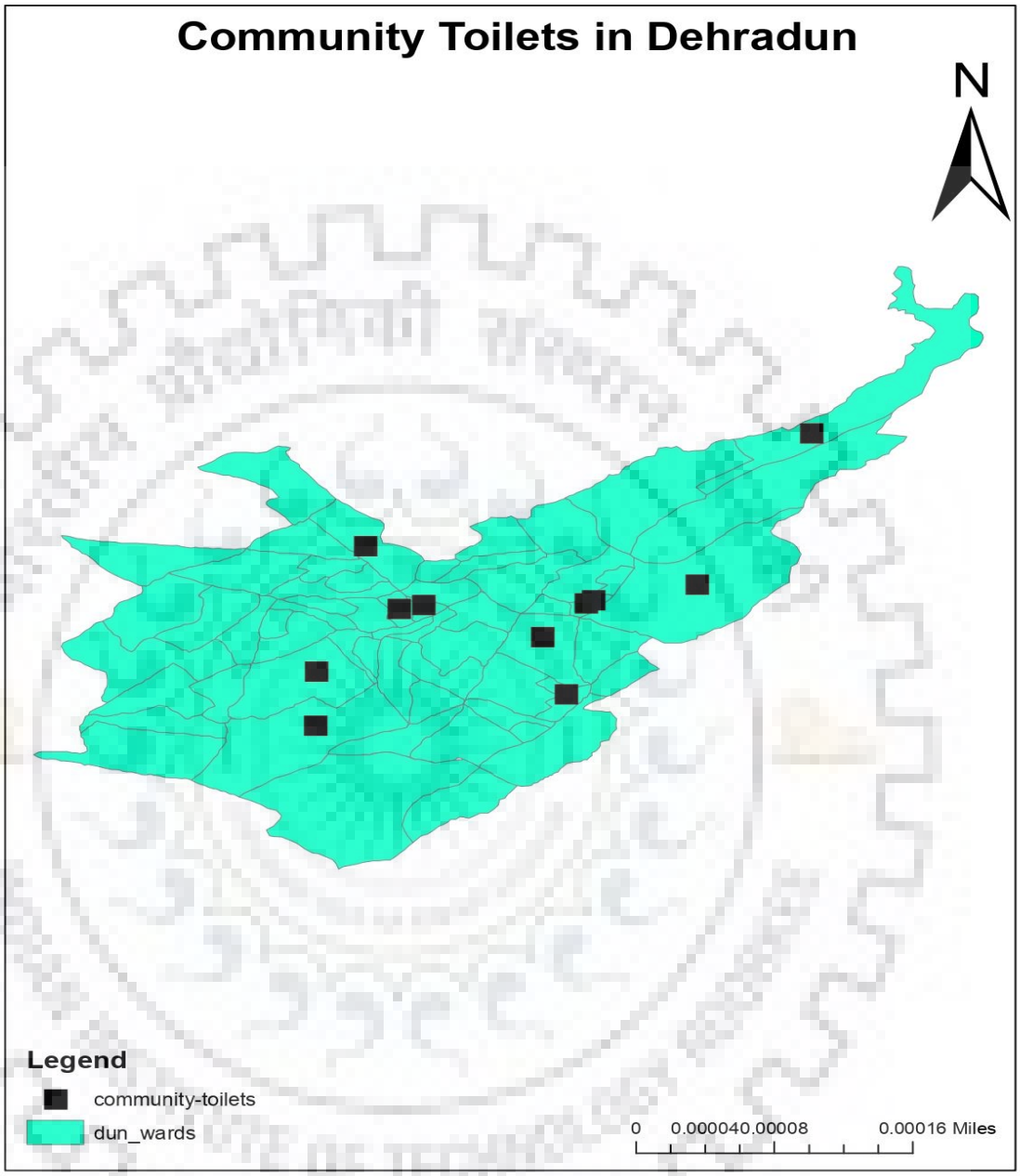


Fig.2.10 Existing Community Toilets in Dehradun

Only 11 community toilets are there in city, which are insufficient. Most of the slums areas are practicing open defecation in absence of their own toilets due to availability of land and money, such areas must be provided with more community toilets in city. Fig 2.10 shows the locations of existing community toilets in the city.

2.4 WATER SUPPLY

Uttarakhand Jal Sansthan (UJS), is an institution which works under the Department of Drinking Water, Government of Uttarakhand (GoU) is responsible for the operation and maintenance of water supply in Dehradun city. Planning of water supply scheme and large capital projects are carried out by Uttarakhand Jal Nigam which is another corporation under Department of Drinking Water, Government of Uttarakhand (GoU. Water supply is supposed to be a function of Municipal Corporation but Dehradun Nagar Nigam (DNN) is in involved in any kind of planning, construction, designing and operation and maintenance services of water supply infrastructures. This section deals with the analysis of current situation of water supply, its problems, key issues and the likely scenario of water supply with respect to water demand, resources, system requirements and related aspects.

2.4.1 POPULATION DATA FOR WATER SUPPLY

Dehradun water supply is covering a large area other than municipal corporation, as per a data available in DEHRADUN WATER SUPPLY RE-ORGANIZATION: PHASE-I UNDER JnNURM, population is tabulated in table 2.11.

Table2.11 Population Forecasting for Water Supply

Year	Permanent Population	Equivalent Floating & Institutional Population @10%	Total Population
2007	717908	71791	789698
2011	823099	82310	905409
2021	1151932	115193	1267125
2031	1508461	150846	1659307
2041	1801864	180186	1982051

Source: Jal Nigam Dehradun (2007)

Taking Per capita water use @135 lcpd+15% loss ie., 155 lpcd and using projected population data total water demand, existing water availability and shortage/surpluses are calculated and shown below in table 2.12.

Table2.12 Water Demand, Availability and Shortage/Surplus

Year	Total Population	Rate of Water supply@135lpcd+15% UAW	Domestic Water Demand(mld)	Water Availability (mld)	Water Shortage(-)/ Surplus(+) (mld)
2007	789698	155.25	122.60	145.40	+22.8
2011	905409	155.25	140.56	145.40	+4.84
2021	1267125	155.25	196.72	145.40	-51.32
2031	1659307	155.25	257.61	145.40	-112.21
2041	1982051	155.25	307.71	145.40	-162.31

Source: Jal Nigam Dehradun

From the above results it is concluded that till 2011 present availability of water is more than demand. But if demand is projected till 2041 there is a shortage of water that must be supplied to meet the water demand of city. More no of tube wells must be built to meet this demand.

2.4.2 AVAILABLE SOURCES OF WATER

Ground water is the main sources of water for Dehradun City from which it meets about 72% of its total supply of 145.40MLD.The rest 28 % or about 40.8 MLD is drawn from the various sources of surface water, as shown in the Table 2.13.

Table2.13 Available Water Sources (Installed Capacity)

S.NO.	NAME OF WATER SOURCE	APPROX. QTY.AVAILABLE(MLD)
1.00	**Surface Source**	
1.01	Kolhukhet spring	1.20
1.02	Mosi fall	12.00
1.03	Bandal River	6.75
1.04	Kalagad	0.85
1.05	Bijapur Canal	10.00
1.06	Galogi	10.00
2.00	**Ground Water sources(tube-wells)**	
2.01	66 tube-wells	104.60
Total Availability in MLD		**145.40**

Source: Jal Nigam Dehradun (2018)

Since Dehradun is situated in a valley having large potential for ground water recharge, abstraction of ground water through deep tube wells have been proved to be quite successful. Presently 66 tube-wells of diameter varying between 150 and 300 mm each about 120 m deep are supplying water to the town.

2.4.3 DISTRIBUTION SYSTEM

Dehradun city is mainly divided in three water supply zones; Gravity flow zone, Pumping flow zone and mixed flow zone. Northern part of city comes under Gravity flow zone which comprise of rajpur and jakhan area, water supply mainly work under gravity flow. Middle part of Dehradun fall in mixed flow zone which consist of Indira colony, kaulagarh, ghantaghar area, where water is supplied through both surface water sources and through tubewell while southern part of city fall in pumping flow zone it comprises old area of city such as Kargi, Dharampur, Majra. Figure 2.11 shows all zones.

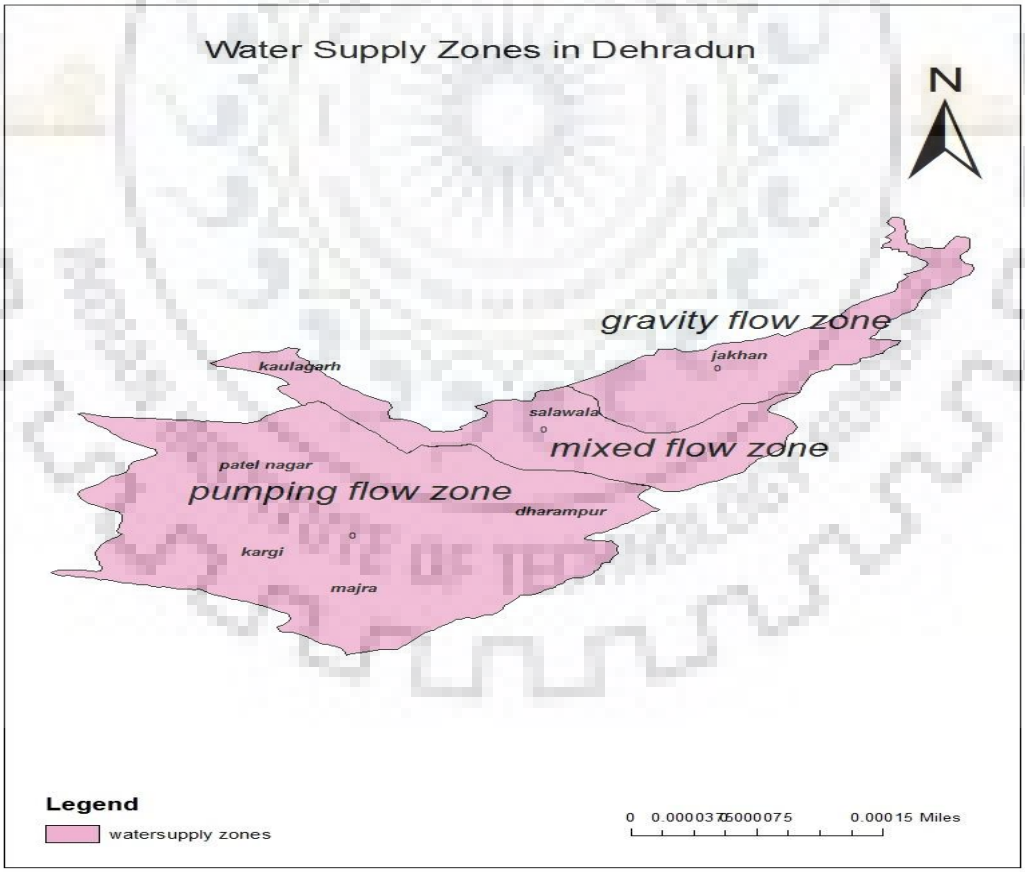


Fig.2.11 Water Supply Zones Dehradun

2.4.4 TRANSMISSION MAINS FOR WATER SUPPLY

Transmission system details are shown below in table 2.14.

Table2.14 Details of Transmission mains

Source to WTP	Length	Condition	Capacity Designed	Capacity Present	Inadequacy
Bandal to Dilaram Bazar	14 km.	Not satisfactory	10 MLD	5 MLD	5 MLD
Massi&Shikar fall to Shahensai Ashram	2 km.	Incrustation in pipe	14 MLD	14 MLD	Nil Mains must be replaced due to depleted condition
Bijapur canal to Dilaram Bazar	4 km.	Satisfactory	12 MLD	12 MLD	Adequate
Galogi to Pururkul Gram	3.5 km,2 nos. Parallel pipes	Satisfactory	12 MLD	12 MLD	Adequate

Source: Jal Nigam Dehradun (2012)

The age in years of the WTPs itself reflects the condition of the structure and its efficiency, but still it is repairable and structurally strong. Quality of water being produced at Dilaram Bazar is potable, but at Shahensai ashram hard water is being produce as water softening plant arrangement does not exists. The water from Galogi source distributed after online chlorination.

2.5 SEWERAGE SYSTEM

Sewerage system in city consists of surface drains, sewers within city, and water flush latrines in households and commercial buildings. Dehradun city is at an elevation of 640 above the mean sea level. City is extended from 600 m to 1000 meter elevation in southern and northern part respectively which provide city a gentle slope of 1:37.5 from north to south.

Dehradun city is having many seasonal nalas and streams. Two main rivers are Rispana and Bindal which is the heart of drainage system of the city. At present about 55 % city is covered with

sewerage system. Remaining population is still using septic tanks and soaks pits; the main reason is the effectiveness of septic tanks and greater depth of water table (80-100 meters).

Currently there are 7 Sewage Treatment plants, most of them are working satisfactory from 2017-18. List of these STP's along with their operational status, treatment technologies and their capacity is given in table 2.15.

Table2.15 List of STP's in Dehradun City

SL.NO.	STP LOCATION	STP INSTALLED CAPACITY MLD	STATUS (OPERATIONAL/ NONOPERATIONAL /UNDER CONSTRUCTION)	TECHNOLOGY (UASB / ASP / OP / SBR / MBR/ FAB ETC.)	UTILISATION OF SLUDGE
1	Kargi (30˚17'12″N & 78˚00'55″E)	68	Operational	SBR	Used for gardening and provide free of cost to local farmers
2	Mothrowala 1 (30˚15'31″N &78˚01'56″E)	20	Operational	SBR	Used for gardening and provide free of cost to local farmers
3	Mothrowala 2 (30˚15'31.56″N &78˚01'55.68″ E)	20	Operational	SBR	Used for gardening and provide free of cost to local farmers
4	Indira nagar (30˚18'46.64″N &77˚59'34″E)	5	Operational	SBR	Gardening in STP premises
5	Vijay colony	0.42	Operational	SBR	Gardening in

	(30˚20’43″N &78˚59’34″E)				STP premises
6	Salawala (30˚20’35″N& 78˚03’24″E)	0.71	Operational	SBR	Gardening in STP premises
7	Jakhan (30˚21’46″N& 78˚03’59.51″E)	1	Operational	SBR	Gardening in STP premises
8	Kaulagarh (30˚21’32″N& 78˚00’45″E)	3	Under construction	SBR	---

Fig 2.12 shows the locations of existing STP’s in Dehradun city.

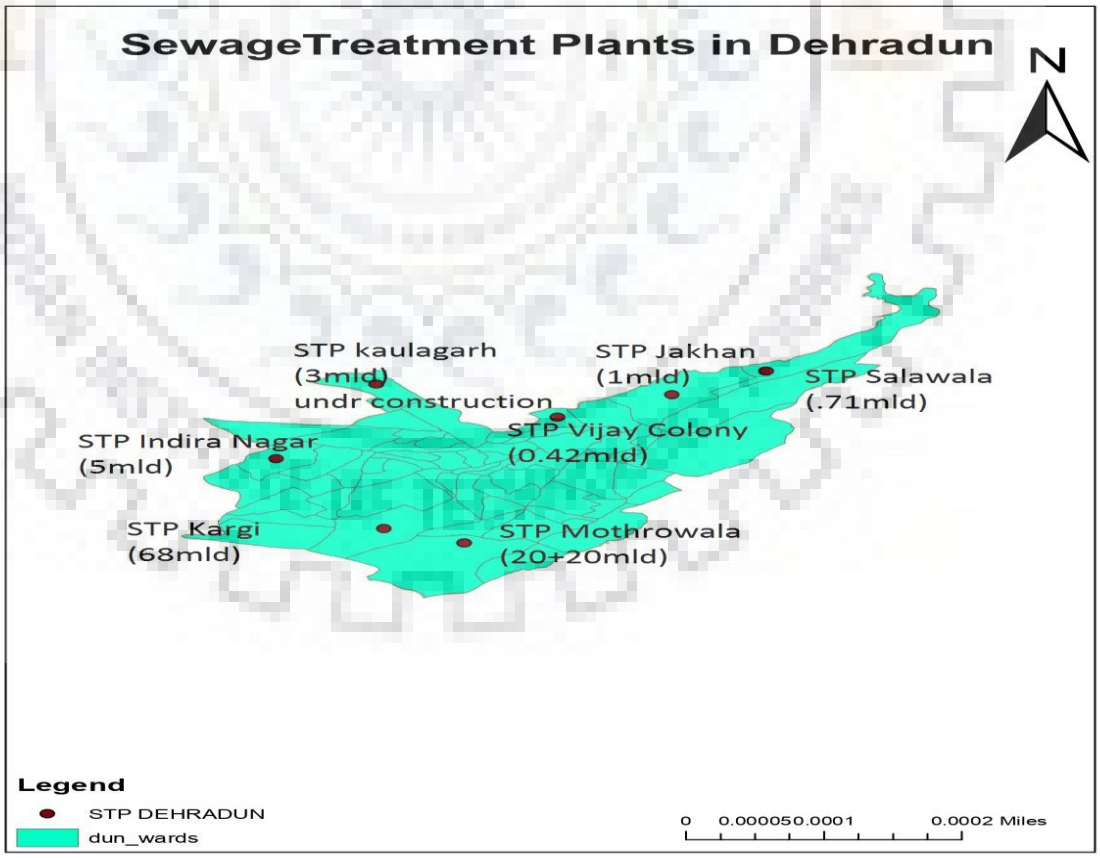


Fig.2.12 Map Showing Existing STP’s in Dehradun

All the STP's are working within their capacity. Kargi STP is discharging outflow treated water into nearby Bindal river and Mothrowala STP's are discharging their treated waste in Rispana river by carrying through concrete pipes. A visit to the SRP's was paid and based on personal discussion with the concerned persons, the following problems are identified:

1. STP's are not getting sufficient inflow sewage to treat to their full capacity. monthly report of STP Kargi is shown below, plant have a capacity of 68 mld but receiving only an average of 14-15 mld daily due to which all the basins are not operational at present. The main reason for this problem is poor coverage of sewerage system in city.

2. Quality of effluent treated water is within permissible limits as shown in table 2.16.

Table2.16 Reported Parameters from STP Visits

Parameters	Average value	Standard value
pH	8	5.5-9
BOD	10 mg/lt	<30
COD	35-50 mg/lt	<250

3. Organic waste (manure) from the plant is either used for gardening in STP premises or given to the farmers free of cost for agricultural operations.

4. Effluents from Septic tanks of residential buildings are also discharged into STP's through Tankers. STP kargi is charging Rs 300/ per tankers for treatment as they have not their own tankers so private tankers are used to carry the liquid waste to plant and by paying Rs 300/ for empting waste in STP.

But Mothrowala plants have their own Tankers and they do not charge any cost for emptying the septic waste in plant. Fig 2.13 (a) to 2.13 (f) show the different treatment steps at STP's in Dehradun.

(a) 68MLD STP Kargi Chawk

(b) Sludge Collection from Centrifuge

(c) Effluent being discharge in Bindal

(d) compost drying at STP Kargi

(e) Septic Tank Emptying at STP (Kargi)

(f) Water Sample (Mothrowala STP)

Fig.2.13 Different treatment steps at STP's in Dehradun

The population of Dehradun municipal area in 2011 was 5,74,840 and it is increasing by 15,234 per year. Therefore the forecasted population of 2019 will be 5,74,840+(15234*8)=6,96,712.

The characteristics of each zone with population are given in table 2.17 below.

Table2.17 Zone Wise STP's Status and Remarks

ZONE	POPULATION (2011)	SEWAGE GENERATION MLD@108lpcd	PRESENT STP CAPACITY	REMARK
I Kargi	3,94,583	42.6	68	• Bindal River drainage Zone, Covers Eastern part of the city. Gravity based system due to natural topography. • 75 % of the population is covered with Sewerage.
II Daudwala	1,79,648	19.4	40	• Rispana River drainage Zone covers western part of the city. Gravity based system due to natural topography. • 35 % population of Zone II covered with sewerage.
III Indira Nagar	51,842	5.6	5	• Saucer shaped topography cannot be connected to main sewer of Kargi, Therefore separate STP is built. • 10% population covered with sewerage.
IV Vijay Colony	7,938	0.85	0.42	• Saucer shaped topography cannot be connected to main sewer of Kargi, Therefore separate STP is built. • 100 % population is

				covered with sewerage.
V Salawala	22,200	2.4	0.71	• Saucer shaped topography cannot be connected to main sewer of Kargi, Therefore separate STP is built. • 10% population covered with sewerage.
VI Doon Vihar	17,565	1.9	1	• Scarcely populated, not economical to connect to Kargi STP, Therefore separate STP is built. • 50 % of the population is covered with sewerage.
VII Other	22,936	2.5	0	• Don't fall under priority schemes. • Partially covered with sewerage

2.6 DRAINAGE SYSTEM

Drainage system of Dehradun city consists of both natural and manmade drains, which form a complex drainage situation in city. Present condition of drainage system is very bad as most of the drains are either unlined or having damaged lining. Garbage is often dumped in the streets which find its way to the drains and leads to the chocking of the drains. Water logging and stagnant water is the main key issues of the city during monsoon periods, water even get enter the houses in some localities like Chandar Road Nayi Basti. Drains are either clogged or broken in many localities because of poor maintenance. Street drains are broken and discontinuous in some areas. These street drains are rarely cleaned. Slums near Rispana and Bindal River get flooded during drain and full of garbage. Rispana and Bindal Rivers are the heart of drainage system of Dehradun City. Both the rivers have a slope from north to south part. There are total 8 drains which cover the whole city:

- Bindal Basin
- Bindal Sub Basin I
- Bindal Sub Basin II

- Bindal Sub Basin III
- Rispana River Basin
- River Asan Basin
- River Dulhani Basin
- Tons Basin

Some stretch of these main drains was lined by DNN with stone and brick masonry and some portion of drains are covered properly but not cleaned on a regular basis. Due to increased population and urbanization, load on these drains are increased with time and these drains require renovation in some portion due to clogging of drain by garbage and polythene bags thrown into them [23]

Some of the localized problems were reported in table 2.18.

Table2.18 Localized Drainage Problems in some areas in Dehradun

S.N.	Name of Area	Drainage Problem
1	Panditwari Area	Drains are closed due to IMA
2	Darshan Lal Chowk	Drains are undersized
3	Race Course Area	Size of Drains are not adequate
4	Sewak Ashram and D.L. Road	Improper Roadside Drains
5	Dalanwala	Improper Roadside Drains
6	Subash and Patel Road	Roadside Drains are clogged
7	Rajiv Nagar	Lack of proper Drains
8	Nehru Colony	Encroachment on Drains

CHAPTER 3
DIFFERENT ELEMENTS OF CSP AND AWARENESS STRETEGY

3.1 GENERAL

Based on the analysis of present status, all the elements of city sanitation plan are discussed in this chapter as per the following points:-

3.2 SOLID WASTE MANAGEMENT

1. There are lots of garbage bins in the city both underground bins and roadside metal bins but collection of garbage from roadside bins need to be done regularly and some places which are (shown in fig 3.1) being ignored must be addressed properly.

2. Many places are identified which are not regularly visited for garbage collection such as dumping area near Nalapani Bridge, Pitthuwala and many places along the Rishpana River and Bindal Rivers.

3. Citizens need to be aware about the segregation of solid waste at household level.

4. There are 2 transfer stations being used regularly, more transfer station are needed for better conveyance of solid waste from different zones of the city.

(a) Garbage Unnoticed alongside road in Pitthuwala

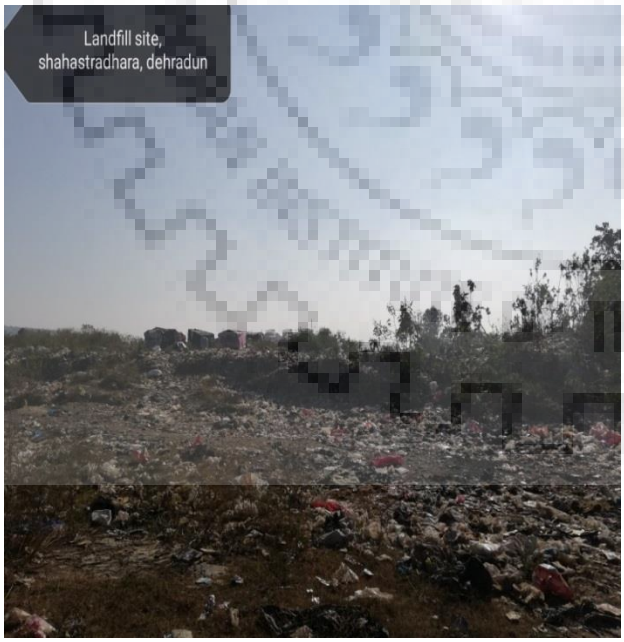
(b) Grabage dumped below Nalapani Bridge

(c) Garbage dumped in Rishpana River

(d) Garbage dumped in Rispana River

Fig.3.1 Garbage thrown at different locations in Dehradun city

5. Trucks which transfer the solid waste from transfer stations are open trucks, due to which waste leak from them and especially during monsoon season. The places near the road side stinks very badly and there is a need to replace these trucks with closed/air tight vehicles. Fig 3.1 (a) to 3.1 (d) shows the garbage thrown at different locations in Dehradun city, which is not noticed by DNN and not being collected regularly.



(a) Dumping Site Shahastradhara Dehradun

(b) Dumping Site Kargi Dehradun

(c) Collection Bins at GMS Road (d) Collection Bin at Mandi

Fig.3.2 Dumping sites at kargi and Shahastradhara alongwith roadside located dustbins

Fig 3.2 (a) and 3.2 (b) shows two dumping sites at Kargi and Shahastradhara area in Dehradun whereas fig 3.2 (c) and 3.2 (d) show roadside located dustbins.

3.3 TOILETS

1. Only 21 public toilets are available in city which is inadequate for such large population, More no of public toilets must be proposed at other important areas of tourist attraction, market places and public parks.

2. Only 11 community toilets are there in city, which are also insufficient. Most of the slums areas are practicing open defecation in absence of their own toilets due to availability of land and money, such areas must be provided with more community toilets in city.

3. Most of the public toilets are not connected with sewerage network and these are emptied with the help of septic tanks in 15 to 20 days, therefore public toilets need to be connected with proper sewage disposal network.

3.4 WATER SUPPLY

1. Total water availability in city at present is 145.40mld, which is sufficient for the existing population but the forecasted water requirement till 2041 is about 307.71mld and therefore there is a shortage of 162.31mld which must be supplied by additional water sources till 2041.

2. Most of the surface sources are used but ground water level of Dehradun city is high and therefore additional tube-wells are needed to satisfy the water demand of the future population.

3. Deterioration of water quality with time requires improvement using water treatment plants.

4. Lack of adequate data base and maps on transmission and distribution system network.

3.5 SEWERAGE SYSTEM

1. Dehradun city have sufficient numbers of STP's but only 55% of city is covered with sewerage network and due to which all the STP's are operation much below their full capacity.

2. Rispana and Bindal Rivers are the heart of sanitation system of the city but both the rivers turned into large drains at present; more study is required to be done on the key reasons for present condition of these rivers and to find creative solution for this problem.

3. Some areas of Prempur Mafi, Saraswati Vihar and Ajabpur Khurd doesn't fall under any sanitation scheme, these areas are must be connected to Kargi STP or Mothrowala STP.

3.6 DRAINAGE SYSTEM

1. Survey and field visit tells that most of the drains in city are in bad condition at present and needs repairing, renovation in nearly half of their lengths. Although the city is well drained but there are some localized issues which are discussed in chapter 4, which are the main reason for stagnation of water and water logging during monsoon period.

2. Dehradun city is expending very fast due to urbanization and migration from different states and hilly areas of the state and land prices were increased very fast in last 2 decades due to this people started living in low lying regions where there is no proper drainage facilities.

3. There are no roadside drains facilities in some old city areas because of space and land constraints.

4. 50 to 60 % population is still using septic tanks and there is no sewerage network in most of the new city areas and they are discharging their waste in these existing drains which is a serious issue for environment and health.

Table 3.1 shows shortages of facilities in different component of sanitation in Dehradun city.

Table3.1 Shortages in Sanitation Facilities

		FACILITIES REQUIRED	FACILITIES AVAILABLE	SHORTAGE
TILL YEAR 2041				
	Solid Waste Treatment	474 MT/day	250 MT/day	224 MT/day
	Transfer Station	6	2	4

MSW	Underground Bins	53	26	27
	Waste to Energy Plant	8.68 MW	Nil	8.68 MW
TOILETS	Public Toilets	41	21	20
WATER SUPPLY	Domestic Water Demand	307.71 MLD	145.40 MLD	162.31 MLD
	Water Treatment Capacity	59 MLD	26 MLD	33 MLD
	Tube-wells	289	66	223
SEWERAGE	Sewage Treatment Capacity	193.7	115.13	78.57

3.7 PUBLIC AWARENESS

For awareness generation the key steps must be taken are; identification of various type of consumers in city, classification of consumers into normal household, slum households, commercial buildings, industrial units, institutions and healthcare units.

The strategy for awareness generation has following objectives;

1. To develop link between hygiene, sanitation behaviors and their health impacts to establish knowledge and awareness for healthy and safe living conditions.

2. To develop mechanism for establishment and sustenance of behavioral changes, this will lead to safe and healthy sanitation practices in city.

3.7.1 NEED FOR SPECIFIC STRATEGY

The information, education and communication (IEC) strategy is needed for analysis of different data on sanitation from existing waste disposal and treatment practices of residents, industrial, commercial and institutional buildings as well as healthcare units. Following groups of people may be involved:

1. Students – awareness generation in early age will be useful for longer time

2. Young generation- good participation of young people is needed

3. Women- women fetch the drinking water for household; they are involved in every sanitation practice in household as well as society.

4. Workforce engaged in informal sector- people working in informal sectors have minimum awareness about sanitation practices

5. Local groups (youth associations, mahila mandals, hotel associations) and NGOs

6. Slums, financial weaker groups

7. Civil societies

8. Hotels, roadside restaurants etc.

9. Public places – commercial areas, railway stations, bus stand etc.

3.7.2 PROPOSED AWARENESS STRATEGY

The city sanitation task force shall be responsible for designing and implementation of awareness strategy in Dehradun city. The proposed awareness strategy has some major elements which are listed below.

- Engagement Of Media And NGOs

The media agency is responsible for development of print materials (brochures, posters, messages etc.) and audio visuals and other forms of public awareness activities such as street plays; local media etc. involvement of NGOs would be beneficial to development of implementation strategies and maximizing the public participation.

- Development Of IEC Materials

The IEC materials must be designed on the basis of behavior of target population, sustainable and low cost technology options for all the recommended sanitation facilities and trend of population (local and floating) increase. Materials should be verified by authorities and representatives of common people before its printing and display.

- Developing Outreach Strategy

Awareness strategies should be developed such that it can reach maximum floating as well as local population. Continuity and effectiveness of strategies should be ensured in terms of cost and reach. Participation of local people, NGOs, relevant partners and stakeholders is necessary.

- Inter-Sectoral Collaborations

Nagar Nigam needs to develop inter-sectoral collaborations with different departments such as public Health Department, Public Works Department and Department of Publicity and Public

Relations. This collaboration can be in the form of providing resources (manpower, materials, money etc.) or including awareness programs in their routines.

- Private Sector Participation

Participation of private partners is very necessary for successful implementation of city sanitation plan. This participation could be in the form of providing funds for organizing awareness programs in the city, development of IEC materials, sharing of cost for infrastructure development and maintenance etc.

- Awareness Campaign

Awareness campaign could be start before all the activities mentioned above it will help in the volunteer participation of NGOs, private sector stakeholders and other departments. Launching of awareness campaign should be done as a formal programme including all the stakeholders and public and private representatives. People must be aware of the launching of this programme, for that posters should be displaced at the public places such as bus stations, railway stations, educational institutes, shopping malls etc.

3.7.3 MONITORING AND REGULATIONS

Campaigns and activities on awareness generation surely help in generating awareness among people but it is not necessary that it would results in required practice and expected behavioral change. To ensure the expected results these activities has to be backed up with-

1. Resources such as garbage collection bins and public toilets in areas where they are not available at present

2. Regular motivation to grow such habits for permanent behavioral change

3. Laws and regulations where required change is not happening

CHAPTER 4
PROPOSED INTERVENTIONS AND COST ESTIMATES

4.1 PROPOSAL FOR IMOROVEMENT IN SWM

City generates around 250 MT solid wastes per day which is being collected door to door in most part of the city. The areas where door to door facility is not available people use nearby bins to dump their waste. Main problem in solid waste management is segregation at source and inadequate numbers of transfer station in city at this time from where the waste gets transported to waste management plant.

1. Segregation at Source:

People need to be educated and aware about the benefit of waste segregation.

Survey shows that people are aware of plastic ban but continuously using plastic begs for their household use and they are not aware of municipal solid waste rule, 2016.

Municipality should organise awareness campaigns at different localities especially in urban slum areas about MSW Rules2016, segregation of waste and should distribute bins which have different compartments for degradable and non-degradable wastes.

2. Transfer Stations: At present there are only 2 transfer stations, as given in table 4.1.

Table4.1 Existing transfer stations in Dehradun

S.N.	Location Name	Total Area (m^2)
1	Kaulagarh(near Temple)	10000
2	Kargi	1240

City needs more transfer station to manage the efficient transportation of solid waste. Some areas are selected to be developed as transfer stations, because these areas are already used for dumping waste and far from households.

3. Proposed Transfer Stations: Table 4.2 gives the list of proposed transfer stations for the city.

Table4.2 Proposed transfer stations for Dehradun city

S.N.	Location Name	Total Area (m^2)
1	Rispana Bridge(near tibatian market)	480
2	Govindgarh(near tample)	500
3	Sahastradhara Road	7490
4	Dhoran area	5250

Fig 4.1 shows the location of existing transfer stations and proposed transfer stations.

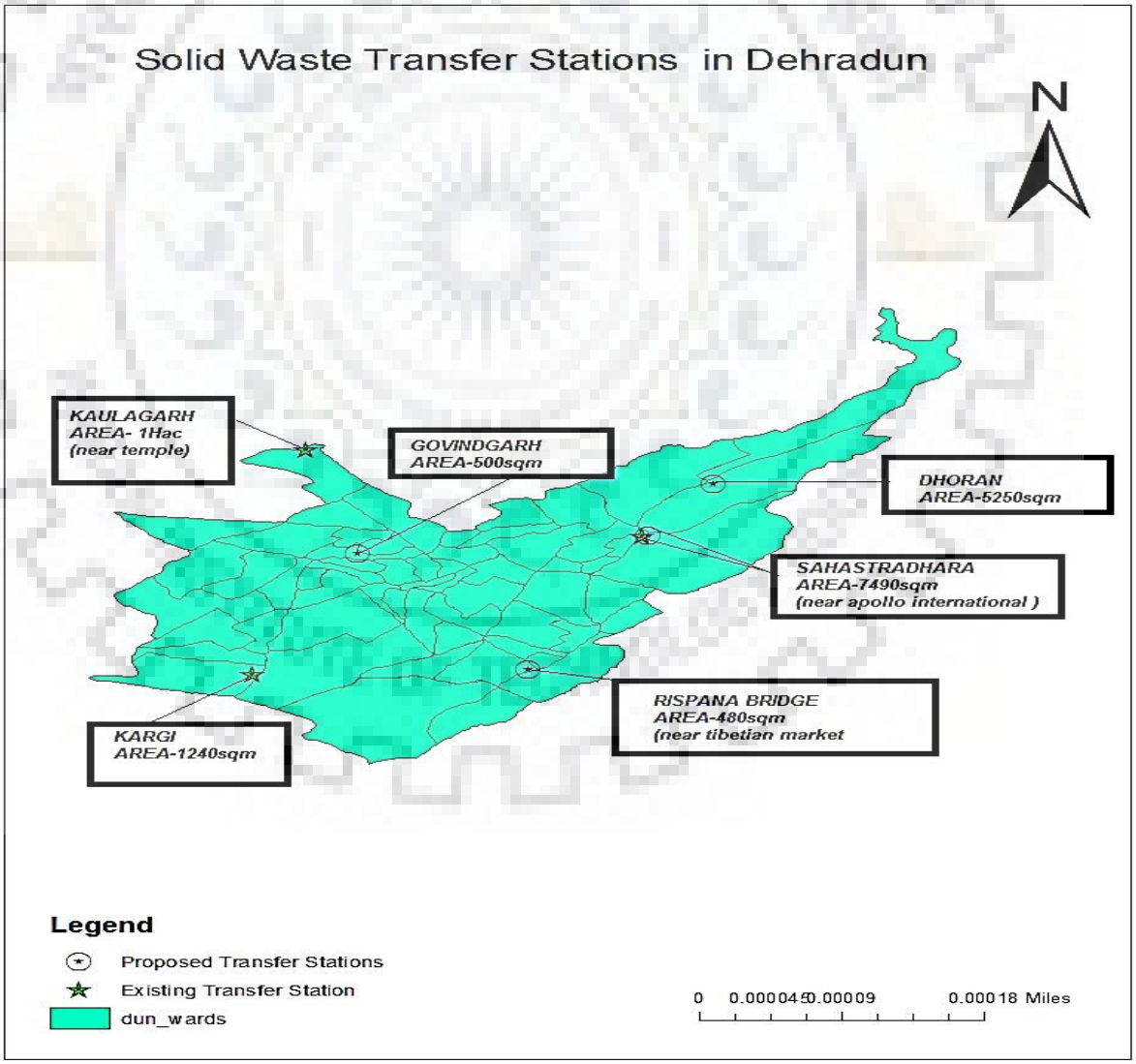


Fig.4.1 Proposed Transfer Stations Location.

4. Underground Bins:

There are total 26 underground bins in the city at present and these are provied in only 19 wards but many wards do not have even single underground bin to dispose the solid waste generated from these areas. More numbers of underground bins are needed in city for proper collection of solid waste from all the wards. Existing bins were plotted on dehradun map and locations of the wards where underground bins were not installed were found out. Table 4.3 below shows proposed underground bins locations in the city.

Table4.3 Proposed underground bins

Ward No.	Location	Capacity			Total
		3cu.m	2.5cu.m	1.5cu.m	
1	Rajpur	2	1	-	3
2	Shahastradhara	2	1	-	3
4	Hathibarkala	-	1	-	1
6	Dobhalwala	-	1	-	1
7	Vijay Colony	1	-	-	1
8	Kishan Nagar	1	-	1	2
11	Karanpur	-	-	1	1
12	Bakralwala	1	-	-	1
15	Clock Tower	-	-	1	1
17	M.K.P	1	-	-	1
25	Dalanwala (North)	1	-	-	1
29	Adhoiwala (South)	1	-	-	1
30	Bhagat Singh Colony	-	1	-	1
52	Vasant Vihar	1	-	-	1
42	Kargi	2	1	-	3
45	Niranjanpur	-	1	-	1
49	Dronapuri	1	-	-	1
50	Kanwali	1	-	-	1
53	Mohit Nagar	1	-	-	1
54	Patel Nagar (west)	1	-	-	1
Total		17	7	3	27

The locations of proposed underground bins are shown in fig 4.2.

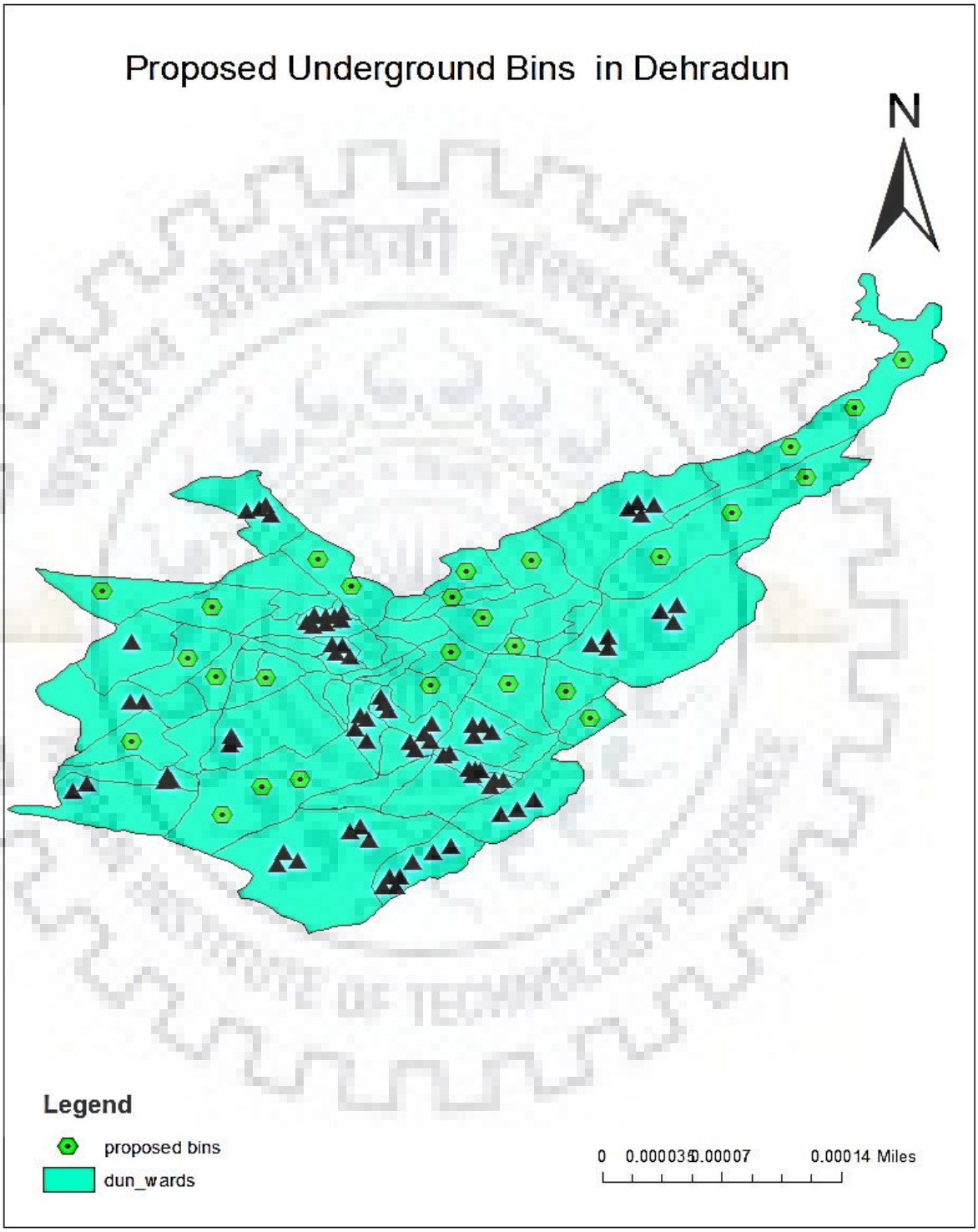


Fig.4.2 Locations of proposed underground bins

5. Waste to Energy Plant

Calorific value of RDF is assumed as 3200 kcal/kg and average generation of RDF in plant is 175 to 200 MT per day. This RDF can be used for generation of syngas by gasification or pyrolysis with air, oxygen or steam. In general 2.5 to 3 m^3 of fuel gas can be generated form 2 kg of RDF. The energy potential of the RDF generated from the plant is found to be 8.68 MW.

POWER GENERATION POTENTIAL

Total Quantity of RDF = 200 TPD

Net Calorific Value Obtained = 3200 Kcal/kg

Conversion Efficiency is assumed as 28%

Theoretical energy recovery potential from 200 TPD is calculated as per the universally accepted general method.

Total RDF (W) = 200 Tones & Net Calorific Value (NCV) = 3200 Kcal/kg

Theoretical energy recovery potential = 1.163*NCV*W Kwh

= 1.163*3200*200 Kwh

= 7,44,320 Kwh

Total Power Generation Potential in KW = 1.163*NCV*W/24

= 1.163*3200*200/24

= 31,013.33 KW

Conversion Efficiency = 28%

Minimum Gross Generation Potential = 31,013.33*.28

= 8683.73 KW

= 8.68 MW

4.2 PROPOSAL FOR IMPROVEMENT OF TOILET FACILITIES

At present there are only total 21 public toilets in the city which are provided only in 14 wards but there are total 61 wards, we need to provide more numbers of public toilets in the city. SBM (Urban) suggest that 1 seat should be available for every 100 users near big shopping stores and commercial areas in the cities [24]. 21 public toilets contain 178 seats which may be sufficient for some areas such as M.K.P. ward contain 5 public toilets, Chhukhuwala contain 3 and Hathibarkala contain 2 public toilets but 47 wards do not have a single public toilet. All the wards were plotted on city ward map in Arc GIS and wards which need public toilets were listed with proposed public toilets in the table below. Table 4.4 shows list of proposed public toilets for Dehradun city. Locations of proposed public toilets are shown in fig 4.3.

Table4.4 Proposed public toilets

Ward No.	Location	No of Toilets	Male	Female	Urinals	Total Seats
1	Rajpur	3	15	10	8	25
2	Sahastradhara	2	10	7	8	17
8	Kishan Nagar	1	5	2	3	7
10	Rispana	1	5	3	2	8
16	Race Course (North)	1	5	4	3	9
24	Jhanda Mohhalla	1	5	3	3	8
28	Adhoiwala	1	5	3	4	8
32	Defence Colony	1	4	3	3	7
33	Nehru Colony	1	5	4	4	9
34	Dharampur	1	4	3	4	7
35	Deep Nagar	1	6	4	4	10
37	Mata Mandir Road	1	5	3	4	8
42	Kargi	1	5	4	4	9
46	Majra	1	5	4	4	9
50	Kanwali	1	4	3	4	7
54	Patel Nagar (West)	1	5	4	3	9
56	Yamuna Colony	1	6	4	5	10
59	Ballupur	1	4	3	3	7

60	Kaulagarh	1	5	3	4	8
Total		20	103	71	73	174

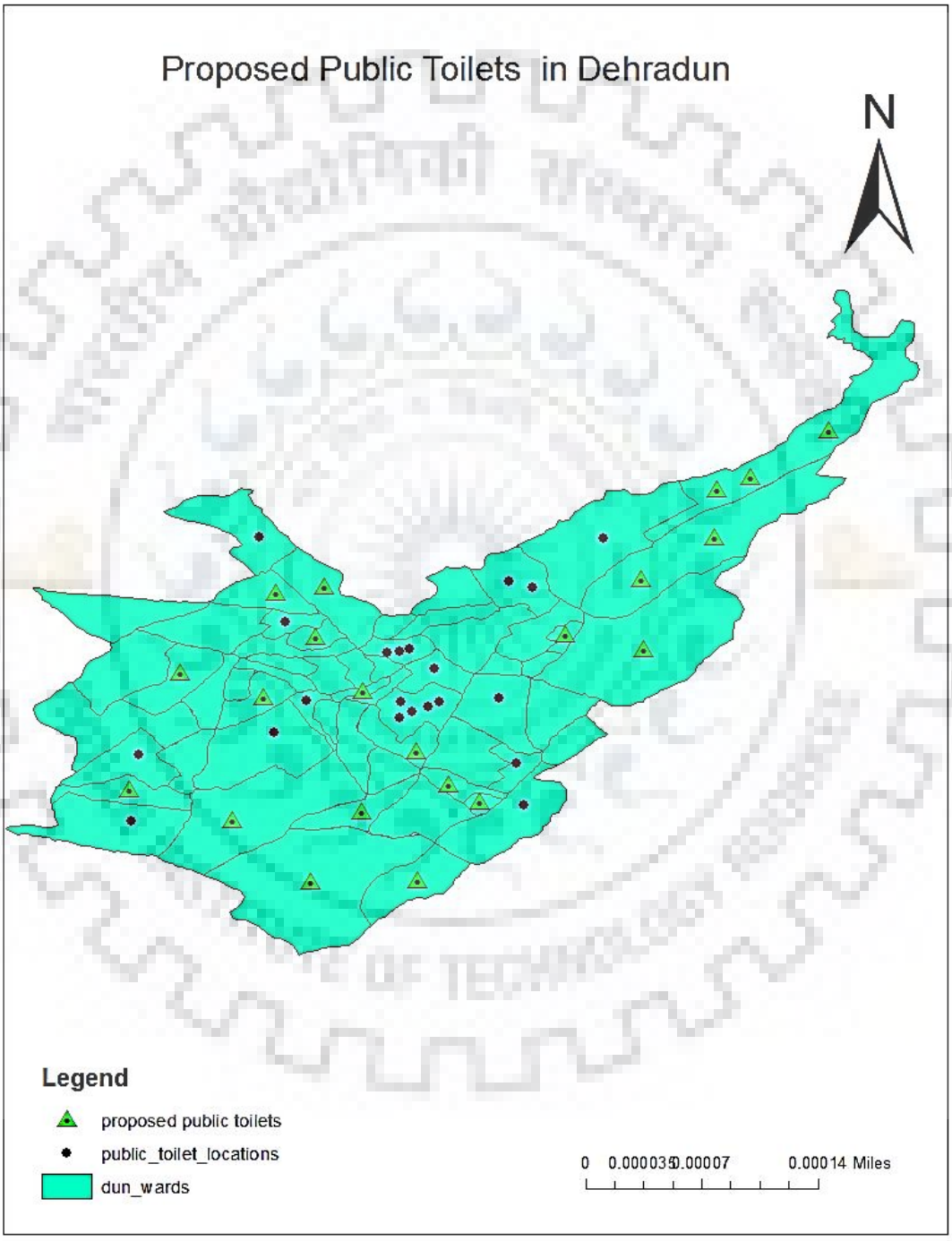


Fig.4.3 Proposed Public Toilets Locations

4.3 PROPOSAL FOR IMOROVEMENT IN WATER SUPPLY

As discussed in chapter 3, at present the water availability in Dehradun city is about 145.40 mld and required water quantity in year 2041 will be about 307.71 mld. All the surface sources are used till now but groundwater level is very good in the city so more tube-wells are required to fulfil this gap in service.

DESIGN PERIOD

Design period is taken 30 years, with base year 2011, immediate stage 2026 and ultimate year 2041.tubewells are designed as per "guidelines on construction & maintenance of bore-wells and tube-wells (January 2014) [25].

POPULATION COVERAGE**:**

Present population(year 2011)	905409
At project completion	
2026	1351031
2041	1982051

CAPACITY IMPROVEMENT:

Present availability	145.40 mld
Required capacity at project completion	
2026	209.75mld
2041	307.71mld
Gap in water availability	
2026	64.35mld
2041	162.31mld

TUBEWELL SPECIFICATIONS:

Depth	80m
Diameter	300mm
Design yield	10,000gph(37854.12lph)

DESIGN YIELD: with continuous pumping yield of tubewell cannot be constant, thus tubewell shall be designed for a rate of discharge 25% more than the required rate of discharge.

Year	Total Design Discharge	No of tubewell required
2026	64.35*1.25=80.4375mld	88
2041	162.31*1.25=202.88mld	223

Therefore 88 tubewells (300mm dia) are needed to be built in first stage till 2026 and total 223 tubewells are needed till 2041. Detailed survey for location is required to be done for the same. For each tubewell, one overhead storage tank must be built with additional 30% storage capacity as a factor of safety.

Transmission Mains

Replacement of 14 km from Bandal to Dilaram Bazar and 2 km between Massi Fall & Shikar Fall to Shahensai Ashram, design diameter of pipelines is 400 mm of C.I. pipes.

Water Treatment Plants

The recommendations for upgradation in existing WTP's in Dehradun are listed below in table 4.5.

Table4.5 Proposal for Up-Gradation in WTP

WTP Location	Present Installation (MLD)	Present Water Quality	Additional Capacity Needed	New-Installation (MLD)	Total Capacity (MLD)	Design Quality
Dilaram Bazaar	16	Potable	4+10	10	30	Potable
Shehensai Ashram	10	Potable	4	--	14	Potable
Purukul Gram	--	Hard	--	15	15	Potable

Distribution System

- Replacement of 250 km stretch distribution lines, with diameter 300 mm. this network would be of Ductile Iron Class K-7 pipes and will minimise distribution loss up to 25%.
- Laying of new distribution lines in new areas of city of about 250 km with diameter 300 mm, Ductile Iron Class K-7 pipes.

Installation of Water Meters

Replacement of 1,25,000 existing water connections with new service connections with meter installed.

4.4 PROPOSAL FOR IMPROVEMENT IN SEWERAGE SYSTEM

There are total 7 STP's currently working in Dehradun city, these STP's are not sufficient for the total amount of sewage waste originating from the city but most of the household are not connected with sewerage system and still using septic tanks to treat their toilet waste, and due to this these STP's not even get enough sewage to operate on full capacity. City needs a plan to connect the entire households to sewerage system. These sections propose improvement in sewerage system till year 2041 which is given in table 4.6.

Table4.6 Required capacity of sewage treatment till 2041

Zone	Present population (2011)	Sewage generation MLD @108lpcd 2011	Forecasted population (2041)	Sewage generation MLD @108lpcd 2041	Present STP capacity 2019	Required STP capacity 2041	Proposed STP capacity
Kargi	394583	42.6	10,20,486	110	68	42	25
Daudwala	179648	19.4	4,64,612	50	40	10	5
Indira Nagar	51842	5.6	1,34,075	14	5	9	5
Vijay colony	7938	0.85	20,529	2.2	0.42	1.78	1
Salawala	22200	2.4	57,414	6.2	0.71	5.49	2.5
Doon	17565	1.9	45,427	4.9	1	3.9	2

Vihar							
Other	22936	2.5	59,317	6.4	0	6.4	4
TOTAL							44.5

4.5 COST ESTIMATION FOR IMPROVEMENT IN SWM

Total cost of Solid Waste Project is estimated on the basis of following aspects:

- Plant and Machinery Cost
- Underground Bins Cost
- Transfer Station Construction and maintenance
- Site Development and ISWM facilities
- Engineering costs
- Preliminary and cost during project operation
- Financing expenses
- Cost for Contingency
- Margin Expenses for Working Capital

Total Cost of the MSW improvement project is found as 16,875 lakhs, Table 4.7 shows different cost considered for calculation of preliminary cost of project [27].

Table 4.7 Cost estimate for improvement in MSW Management

Project cost description	C&T facility (Lakhs)	WTE Plant (Lakhs)	To be Incurred (Lakhs)	TOTAL (Lakhs)
Plant and Machinery	9800	19000	28800	28800
Building & civil	-	3300	8000	8000
Transfer Station (150lakhs/unit)	600	-	600	600
Transmission cost	-	1200	1200	1200
Total hard cost	**10400**	**23500**	**33900**	**33900**
Contingency(2% of hard cost)	208	470	678	678
Engineering & Consultancy	25	1190	1215	1215
Preliminary & Pre-operative Cost	2350	1180	3530	3530

Financing (1.5% of hard cost)	156	352.2	508.5	508.5
Interest during construction (9%)	936	2115	3051	3051
Margin Money (1%)	104	235	339	339
Total Soft Costs	**3779**	**5542.2**	**9321.2**	**9321.2**
Total Project Cost	**14179**	**29042.2**	**43221.2**	**43221.2**

4.6 COST ESTIMATION FOR TOILETS

Table 4.8 give the preliminary cost estimate for public toilets proposed for Dehradun city [24].

Table4.8 Cost Estimate for Toilets

S.N.	Description of work	Cost per seat (Lakhs)	Total seats	Total cost (Lakhs)
1	Construction of public toilets	0.75	174	130.5
2	Construction of public urinals	0.75	73	54.75
Total capital Cost				185.25
Operation and Maintenance Cost				
3	Maintenance of toilets	0.1	174	17.4
4	Maintenance of urinals	0.08	73	5.84
Total O&M Cost				23.24
Total Capital Cost				**185.25**
5 years O&M Cost				**116.2**

4.7 COST ESTIMATION FOR WATER SUPPLY

Estimated cost for improvement in water supply is given in table 4.9 [22].

Table4.9 Cost Estimate for Water Supply

Description of Work	Cost per unit	Amount (Lakhs)
I. Basic Cost		
1. Up-Gradation of Dilaram Bazar WTP, Shehensai WTP and Installation of new		2,353

Purukul Gram WTP		
2. Laying of 2 km water main from Massi and Shikar Fall to Shehensai WTP and 14 km Bandal to Dilaram Bazar (C.I. pipes)	Rs.10,209.65 per meter	1,633.54
3. Installation of water meter in 1,25,000 households		4,560
4. Replacement of 250km distribution line and laying of new 250 km distribution lines(D.I. pipes)	Rs.3305 per meter	16,525
5. Installation of 223 Tubewells (300mm dia, 80m depth)	Rs.370.70 per meter	66.14
6. Hydro-Geological Study for identification of new location for new Tubewells and Overhead Tanks		35
7.Rehabilitation of existing Tubewells		10
Sub-Total(I)		25,182.68
II. Contingencies		
a) Add 10% price contingencies		2,518.26
b) Add 5% physical contingencies		1,259.13
Sub Total(II)		3,777.39
Grand Total(I+II)		**28,960**

4.8 COST ESTIMATION FOR SEWERAGE SYSTEM

44.5 MLD sewage treatment plant capacity is proposed in whole city till 2041 in chapter 6. Preliminary cost of building sewerage system for 44.5 MLD is estimated in the table 4.10 below [26].

Table4.10 Cost estimate for STP's

Capacity	44.5 MLD
Capital Cost Per MLD	90 Lakhs
Total Cost for 44.5 MLD	4005 Lakhs
Total Annual Operation and Maintenance Cost Per MLD	

Power Usage (Kwh/d/MLD)	187
Power Cost Per Unit	5.5 INR
Yearly Power Cost	3.75 Lakhs
Repair Cost	2 Lakhs
Chemical Cost	1.1 Lakhs
Manpower Cost	10 Lakhs
Total O&M Cost	16.85 Lakhs
Total O&M Cost for 44.5 MLD	749.82 Lakhs
Capital Cost	**4005 Lakhs**
Interest Rate (12%)	.12
Annual Amortized Cost	497.12 Lakhs
Total Annual Cost for 44.5 MLD	**1247 Lakhs**

4.9 TOTAL COST

Table4.11 Total Cost Estimate of all elements of CSP

S.N.	Description	Cost (Lakhs)
1	MSW	43,221.2
2	Toilets	301.45
3	Water Supply	28,960
4	Sewerage	5,252
Total		777,34.65

Thus the overall cost of project is approx. 777.34 crores.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

From the present study and analysis of existing sanitation situations in the city and proposal for all components of city sanitation plan following conclusions can be drawn:

5.1.1 SOLID WASTE MANAGEMENT

Dehradun city generates around 250MT/day, which is being treated in solid waste plant in Shishambada but the real time problem is the segregation of solid waste at source, and use of RDF being generated as an end product of solid waste treatment. There are only 28 underground bins and 3 transfer stations in the city which is not sufficient.

5.1.2 WATER SUPPLY

Per capita water demand for Dehradun city is assumed as 135 lpcd plus 15% loss. At present water availability in city is about 145.40 mld and for 2041 water demand will be around 307.71mld, city will lack by 162.31 mld till 2041. Water treatment plants are old and softening units are not available there.

5.1.3 TOILETS

At present there are total 21 public toilets and 11 community toilets available in the city. These toilets have their own septic tanks, which get filled within 15 days and have to be emptied in that interval. Around 200 to 250 people use these public toilets regularly which result in generation of around 500 to 600 INR per day.

5.1.4 SEWERAGE AND SANITATION SYSTEM

There are total 7 STPs which are under operational condition, capacity is sufficient for present population because around 50% population is still using soak pits for disposal of sewage at household level. These STPs are running well but didn't get sufficient inflow even to operate at full capacity; this is a problem at the time of non-monsoon period. Some areas such as Premnagar Mafi, Saraswati Vihar, and Ajabpur Khurd which are not connected to any STPs till now.

5.2 RECOMMENDATIONS

5.2.1 SOLID WASTE MANAGEMENT

There is urgent need of awareness generation regarding solid waste management rules and policies in Dehradun and especially about the importance of solid waste segregation at source.

City needs development of more transfer station which should be completely covered so that garbage will not spread around. There are 26 underground bins at present in the city some wards are without underground bins at present, therefore more numbers of underground bins are needed in city.

Shishambada waste treatment plant generate around 200MT of RDF per day which can be used for energy generation. A 8.68 MW waste to energy plant is recommended near the waste treatment plant in the city.

5.2.2 WATER SUPPLY

Water needs to distribute evenly to all zones, for that water must be exported to those wards where there is a water deficit at present. Total 88 tubewells are recommended till 2026 and 223 tubewells till 2041 to meet the water demand in future. Water treatment plant need upgradation and distribution system needs renovation in most areas.

5.2.3 TOILETS

20 public toilets are recommended for the city, in those wards where their no public toilets are available at present or the areas which are center for floating population. As per the SBM guidelines for public toilets 1 seat is needed for 100 users in public places. Public toilets and community toilets should be regularly cleaned and maintained.

5.2.4 SEWARAGE AND SANITATION

Till year 2041, additional 44.5mld capacity for sewage treatment plant is required at various sewerage zones and most of the areas need to be connected to sewerage network which are still using septic tanks for sewage disposal at their households.

More and more aspects may be taken for effecting CSP for Dehradun and other cities in order to improve sanitation and hygienic condition of its people.

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