ENVIRONMENTAL IMPACT OF SOLID WASTE NEAR SALOGRA DUMP SITE, SOLAN

A Thesis

Submitted in partial fulfillment of the requirements for the award of the degree of

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IN

CIVIL ENGINEERING

With specialization in

ENVIRONMENTAL ENGINEERING

Under the supervision of

Dr. Rajiv Ganguly

By

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN – 173 234

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CERTIFICATE

This is to certify that the work which is being presented in the project title **"Environmental Impact of Solid Waste near Salogra Dump Site, Solan"** in partial fulfillment of the requirements for the award of the degree of Master of Technology in civil engineering with specialization in "**Environmental Engineering**" and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Deepika Sharma** during a period from July 2015 to May 2016 under the supervision of **Dr. Rajiv Ganguly** Associate Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

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CANDIDATE'S DECLARATION

I hereby declare that the work titled **"Environmental Impact of Solid Waste near Salogra Dump Site, Solan"** carried under the guidance of **Dr. Rajiv Ganguly** in fulfillment for the award of degree of Master of Technology in Environmental Engineering to **Jaypee University of Information Technology, Waknaghat-Solan** has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree or diploma.

Date: 30 May, 2016 **Deepika Sharma**

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Date: 30 May, 2016 **Deepika Sharma**

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ABBREVIATIONS

COD - Chemical Oxygen Demand

BOD - Biological Oxygen Demand

TKN - Total Kjeldhal Nitrogen

TDS - Total Dissolved Solids

SO_4^{2-} - Sulphate

NO_3^- - Nitrate

MPN - Most Probable Number

SWM- Solid waste management

E. coli - Escherichia coli

AAS - Atomic Absorption Spectrometer

EC - Electrical conductivity

WHO – World Health Organisation

mg/L - milligram per Litre

mg/kg – milligram per kilogram

Abstract

In the present study, the physico-chemical, bacteriological and heavy metal testing carried out for leachate, surface, ground water and soil samples collected from municipal solid waste landfill site and different water sources in Sologra, Solan to find out the effect of leachate percolation on environment. Testing was done for two seasons. Physico-chemical parameters analysed were, pH, Total Dissolve Solid (TDS), sulphate, turbidity, Electrical Conductivity (EC) while biological parameters tested were Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Most Probable Number (MPN) test and ammonical nitrogen. Testing for heavy metals (Pb, Zn, Cr, Ni, and Fe) was carried out and has been reported. AAS was used to determine the metal contents. The results were compared with the WHO standards for drinking water quality. The results reveal that the leachate from the unlined landfill may have a significant impact on the groundwater resource (often used as drinking source) particularly because of the toxic nature of the leachate coupled with the soil characteristics which is permeable in nature.

The research work dispense the indicator set for integrated sustainable waste management in different cities to allow the benchmarking of the cities performance, comparing cities and monitoring development over time. The analysis results shows that the Solan city don't have adequate solid waste management system till the present time.

Key words: Groundwater, Heavy Metals, landfill, leachate, municipal solid waste, Solan

Chapter 1

Introduction

1.1.1 Definition of waste

Solid wastes are the organic and inorganic waste materials such as product packaging, grass clippings, furniture, clothing, bottles, kitchen refuse, paper, appliances, paint cans, batteries, etc., produced in a society, which do not generally carry any value to the first user(s). Solid wastes, thus, encompass both a heterogeneous mass of wastes from the urban community as well as a more homogeneous accumulation of agricultural, industrial and mineral wastes. While wastes have little or no value in one setting or to the one who wants to dispose them, the discharged wastes may gain significant value in another setting. Knowledge of the sources and types of solid wastes as well as the information on composition and the rate at which wastes are generated/ disposed is, therefore, essential for the design and operation of the functional elements associated with the management of solid wastes. Solid wastes are classified on the basis of source of generation and type.

1.1.2 Source-based classification

Historically, the sources of solid wastes have been consistent, dependent on sectors and different activities (Tchobanoglous, et al., 1977), which include the following:

(i) **Residential:** This refers to wastes from dwellings, apartments, etc., and consists of leftover food, vegetable peels, plastic, clothes, ashes, etc.

(ii) **Commercial:** This refers to wastes consisting of leftover food, glasses, metals, ashes, etc., generated from stores, restaurants, markets, hotels, motels, auto-repair shops, medical facilities, etc.

(iii) **Institutional:** This mainly consists of paper, plastic, glasses, etc., generated from educational, administrative and public buildings such as schools, colleges, offices, prisons, etc.

(iv) **Municipal:** This includes dust, leafy matter, building debris, treatment plant residual sludge, etc., generated from various municipal activities like construction and demolition, street cleaning, landscaping, etc.

(v) **Industrial:** This mainly consists of process wastes, ashes, demolition and construction wastes**,** hazardous wastes, etc., due to industrial activities.

(vi) **Agricultural:** This mainly consists of spoiled food grains and vegetables, agricultural remains, litter, etc., generated from fields, orchards, vineyards, farms, etc.

(vii) **Open areas**: This includes wastes from areas such as streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas, etc.

1.1.3 Type-based classification

Classification of wastes based on types, i.e., physical, chemical, and biological characteristics of wastes, is as follows (Phelps, et al., 1995)

(i) **Garbage**: This refers to animal and vegetable wastes resulting from the handling, sale, storage, preparation, cooking and serving of food. Garbage comprising these wastes contains putrescible (rotting) organic matter, which produces an obnoxious odour and attracts rats and other vermin. It, therefore, requires special attention in storage, handling and disposal.

(ii) **Ashes and residues**: These are substances remaining from the burning of wood, coal, charcoal, coke and other combustible materials for cooking and heating in houses, institutions and small industrial establishments.. Ashes consist of fine powdery residue, cinders and clinker often mixed with small pieces of metal and glass. Since ashes and residues are almost entirely inorganic, they are valuable in landfills.

(iii) **Combustible and non-combustible wastes**: These consist of wastes generated from households, institutions, commercial activities, etc., excluding food wastes and other highly putrescible material. Typically, while combustible material consists of paper, cardboard, textile, rubber, garden trimmings, etc., non-combustible material consists of such items as glass, crockery, tin and aluminium cans, ferrous and non-ferrous material and dirt.

(iv) **Bulky wastes**: These include large household appliances such as refrigerators, washing machines, furniture, crates, vehicle parts, tyres, wood, trees and branches. Since these household wastes cannot be accommodated in normal storage containers, they require a special collection mechanism.

(v) **Street wastes**: These refer to wastes that are collected from streets, walkways, alleys, parks and vacant plots, and include paper, cardboard, plastics, dirt, leaves and other vegetable matter. Littering in public places is indeed a widespread and acute problem in many countries including India, and a solid waste management system must address this menace appropriately.

(vi) **Biodegradable and non-biodegradable wastes**: Biodegradable wastes mainly refer to substances consisting of organic matter such as leftover food, vegetable and fruit peels, paper, textile, wood, etc., generated from various household and industrial activities. Because of the action of micro-organisms, these wastes are degraded from complex to simpler compounds. Non-biodegradable wastes consist of inorganic and recyclable materials such as plastic, glass, cans, metals, etc. Figure below shows a comparison of biodegradable and non-biodegradable wastes with their degeneration time, i.e., the time required to break from a complex to a simple biological form:

Table 1.1 Biodegradable and Non-Biodegradable Wastes Degeneration Time

Category	Type of waste	Approximate time take to degenerate
Biodegradable	Organic waste such as vegetable and fruit peels etc	A week or two
	Paper	10 -30 days
	Cotton cloth	2-5 months
	Woollen item	1 year
	Wood	10-15year
Non- biodegradable	Tin, aluminium and other metal items such as cans	100-500 year
	Plastic bags	One million years
	Glass bottles	Undetermined

(vii) Dead animals: With regard to municipal wastes, dead animals are those that die naturally or are accidentally killed on the road. Note that this category does not include carcasses and animal parts from slaughter-houses, which are regarded as industrial wastes. Dead animals are divided into two groups – large and small. Among the large animals are horses, cows, goats, sheep, pigs, etc., and among the small ones are dogs, cats, rabbits, rats, etc. The reason for this differentiation is that large animals require special equipment for lifting and handling when they are removed. If not collected promptly, dead animals pose a threat to public health since they attract flies and other vermin as they decay. Their presence in public places is particularly offensive from the aesthetic point of view as well.

(viii) Abandoned vehicles: This category includes automobiles, trucks and trailers that are abandoned on streets and other public places. However, abandoned vehicles have significant scrap value for their metal, and their value to collectors is highly variable. .

(**ix) Farm wastes:** These wastes result from diverse agricultural activities such as planting, harvesting, production of milk, rearing of animals for slaughter and the operation of feedlots. In many areas, the disposal of animal waste has become a critical problem, especially from feedlots, poultry farms and dairies.

(x) Hazardous wastes: Hazardous wastes are those defined as wastes of industrial, institutional or consumer origin that are potentially dangerous either immediately or over a period of time to human beings and the environment. This is due to their physical, chemical and biological or radioactive characteristics like ignitability, corrosivity, reactivity and toxicity. Note that in some cases, the active agents may be liquid or gaseous hazardous wastes. These are, nevertheless, classified as solid wastes as they are confined in solid containers. Typical examples of hazardous wastes are empty containers of solvents, paints and pesticides, which are frequently mixed with municipal wastes and become part of the urban waste stream. Certain hazardous wastes may cause explosions in incinerators and fires at landfill sites. Others such as pathological wastes from hospitals and radioactive wastes also require special handling. Effective management practices should ensure that hazardous wastes are stored, collected, transported and disposed of separately, preferably after suitable treatment to render them harmless. We will discuss hazardous wastes in detail

(xi) Medical waste: Wastes from health posts, clinics, hospitals, and other medical facilities pose serious and urgent problems .These wastes can contain highly infectious organisms, sharp objects, hazardous pharmaceuticals and chemicals, and even radioactive materials. Since the various forms of healthcare waste require different types of treatment, they should be segregated at the source. General waste should be segregated from hazardous material to reduce volume: sharps should be placed in puncture-proof containers, infectious waste separated for sterilization, and hazardous chemicals and pharmaceuticals segregated into separate bins.
Unfortunately, all of the available disposal options are imperfect. The most immediate threat comes from highly infectious waste. On-site treatment is generally preferred to reduce the risk of disease transmission to waste handlers, waste pickers and others.

(xii) Tires, oil and batteries: These three common automotive wastes cause difficulties throughout the continent: Stockpiled tires can spontaneously combust, producing prolonged, polluting fires. Reuse or retreading are the best alternatives available for reducing tire waste in developing and industrializing countries. Lead acid batteries should not be placed in landfills—the lead is toxic, the acid corrosive and contaminated. Lead acid batteries are often recycled in small-scale foundries that are highly polluting and located in residential areas. Recycling in large facilities that have emission and environmental controls is preferable, if this option is available.

(xiii) Sewage wastes: The solid by-products of sewage treatment are classified as sewage wastes. They are mostly organic and derived from the treatment of organic sludge separated from both raw and treated sewages. The inorganic fraction of raw sewage such as grit and eggshells is separated at the preliminary stage of treatment, as it may entrain putrescible organic matter with pathogens and must be buried without delay. The bulk of treated, dewatered sludge is useful as a soil conditioner but is invariably uneconomical. Solid sludge, therefore, enters the stream of municipal wastes, unless special arrangements are made for its disposal.

1.2 Solid waste management

A SWM system refers to a combination of various functional elements associated with the management of solid wastes. The system, when put in place, facilitates the collection and disposal of solid wastes in the community at minimal costs, while preserving public health and ensuring little or minimal adverse impact on the environment. The functional elements that constitute the system are:

(i) Waste generation: Wastes are generated at the start of any process, and thereafter, at every stage as raw materials are converted into goods for consumption. Wastes are generated from households, commercial areas, industries, institutions, street cleaning and other municipal services. The most important aspect of this part of the SWM system is the identification of waste.

(ii) Waste storage: Storage is a key functional element because collection of wastes never takes place at the source or at the time of their generation. The heterogeneous wastes generated in residential areas must be removed within 8 days due to shortage of storage space and presence of biodegradable material. Onsite storage is of primary importance due to aesthetic consideration, public health and economics involved. Some of the options for storage are plastic containers, conventional dustbins (of households), used oil drums, large storage bins (for institutions and commercial areas or servicing depots), etc. Obviously, these vary greatly in size, form and material.

(iii) Waste collection: This includes gathering of wastes and hauling them to the location, where the collection vehicle is emptied, which may be a transfer station (i.e., intermediate station where wastes from smaller vehicles are transferred to larger ones and also segregated), a processing plant or a disposal site. Collection depends on the number of containers, frequency of collection, types of collection services and routes. Typically, collection is provided under various management arrangements, ranging from municipal services to franchised services, and under various forms of contracts.

(iv) Transfer and transport: This functional element involves:

The transfer of wastes from smaller collection vehicles, where necessary to overcome the problem of narrow access lanes, to larger ones at transfer stations; the subsequent transport of the wastes, usually over long distances, to disposal sites. The factors that contribute to the designing of a transfer station include the type of transfer operation, capacity, equipment, accessories and environmental requirements.

a) Processing: Processing is required to alter the physical and chemical characteristics of wastes for energy and resource recovery and recycling. The important processing techniques include compaction, thermal volume reduction, manual separation of waste components, incineration and composting.

b) Recovery and recycling: This includes various techniques, equipment and facilities used to improve both the efficiency of disposal system and recovery of usable material and energy. Recovery involves the separation of valuable resources from the mixed solid wastes, delivered at transfer stations or processing plants. It also involves size reduction and density separation by air classifier, magnetic device for iron and screens for glass. The selection of any recovery process is a function of economics, i.e., costs of separation versus the recovered-material products. Certain recovered materials like glass, plastics, paper, etc., can be recycled as they have economic value.

c) Waste disposal: Disposal is the ultimate fate of all solid wastes, be they residential wastes, semi-solid wastes from municipal and industrial treatment

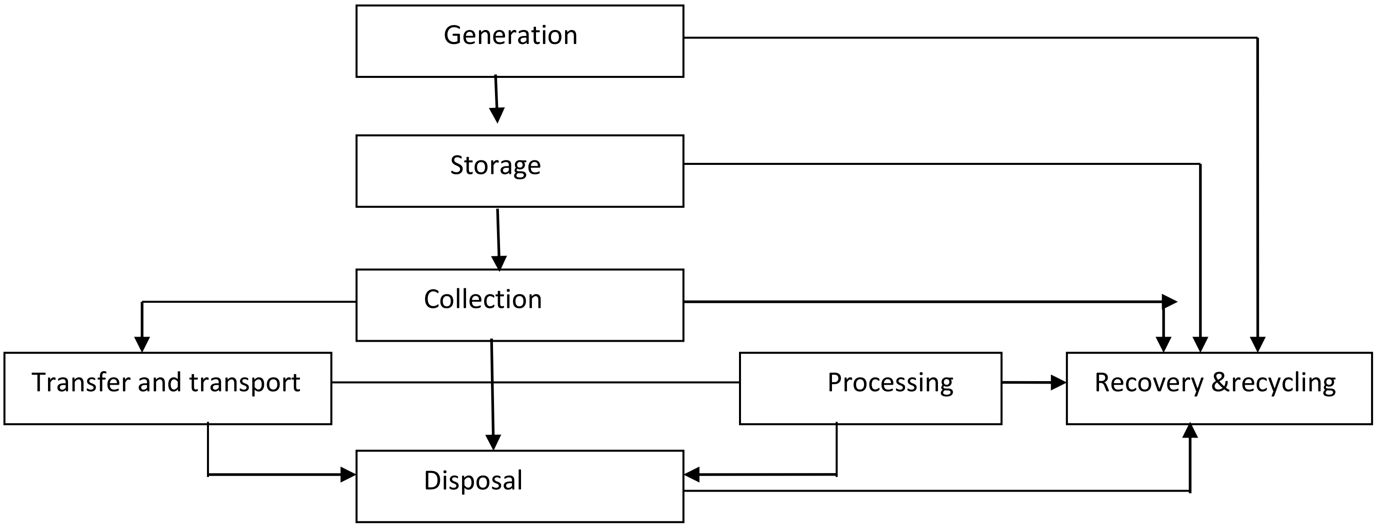

Figure 1.1 Typical SWM Systems: Functional Elements

1.3 Potential Environmental Impacts from Solid Waste Management Activities

The typical municipal solid waste stream will contain general wastes (organics and recyclables), special wastes (household hazardous, medical, and industrial waste), and construction and demolition debris. Most adverse environmental impacts from solid waste management are rooted in inadequate or incomplete collection and recovery of recyclable or reusable wastes, as well as co disposal of hazardous wastes. These impacts are also due to inappropriate siting, design, operation, or maintenance of dumps and landfills. Improper waste management activities can Environmental Guidelines for Small-Scale Activities in Africa (2009):

1) Increase disease transmission or otherwise threaten public health: Rotting organic materials pose great public health risks, including, as mentioned above, serving as breeding grounds for disease vectors. Waste handlers and waste pickers are especially vulnerable and may also become vectors, contracting and transmitting diseases when human or animal excreta or medical wastes are in the waste stream. (See the discussion on medical wastes below and the separate section on "Healthcare Waste: Generation, Handling, Treatment, and Disposal" in this volume. Risks of poisoning, cancer, birth defects, and other ailments are also high.

2) Contaminate ground and surface water: Municipal solid waste streams can bleed toxic materials and pathogenic organisms into the leachate of dumps and landfills. (Leachate is the liquid discharge of dumps and landfills; it is composed of rotted organic waste, liquid wastes, infiltrated rainwater and extracts of soluble material.) If the landfill is unlined, this runoff can contaminate ground or surface water, depending on the drainage system and the composition of the underlying soils.

4) Create greenhouse gas emissions and other air pollutants: When organic wastes are disposed of in deep dumps or landfills, they undergo anaerobic degradation and become significant sources of methane, a gas with 21 times the effect of carbon dioxide in trapping heat in the atmosphere.

6) Damage ecosystems: When solid waste is dumped into rivers or streams it can alter aquatic habitats and harm native plants and animals. The high nutrient content in organic wastes can deplete dissolved oxygen in water bodies, denying oxygen to fish and other aquatic life form. Solids can cause sedimentation and change stream flow and bottom habitat. Siting dumps or landfills in sensitive ecosystems may destroy or significantly damage these valuable natural resources and the services they provide.

7) Injure people and property. In locations where shantytowns or slums exist near open dumps or near badly designed or operated landfills, landslides or fires can destroy homes and injure or kill residents. The accumulation of waste along streets may present physical hazards, clog drains and cause localized flooding.

8) **Discourages tourism and other business**: The unpleasant odour and unattractive appearance of piles of uncollected solid waste along streets and in fields, forests and other natural areas, can discourage tourism and the establishment and/or maintenance of businesses.

1.4 World scenario

Municipal solid waste (MSW), one of the most important by-products of a country, is growing very fast with increasing the urban population. In last decade, there were 2.9 billion urban residents who generated about 0.64 kg of MSW per person per day (0.68 billion tonnes per year). The amount of municipal solid waste will rise from the current 1.3bn tonnes a year to 2.2bn by 2025. The annual cost of solid waste management is projected to rise from $205bn to $375bn, with cost increasing most sharply in poorer countries.

According to World Bank, China’s whopping 190 million tons of waste every year is not totally properly disposed. Only less than 50 % of China’s solid wastes are treated properly, whether it is through landfill or incineration. China is not alone. Other Asian countries, like India, Indonesia and the Philippines also have poor waste disposal methods in developing countries the problem of solid waste management is more challengeable because of large population lack of financial resources and lack of technologies for dealing the waste or its management.

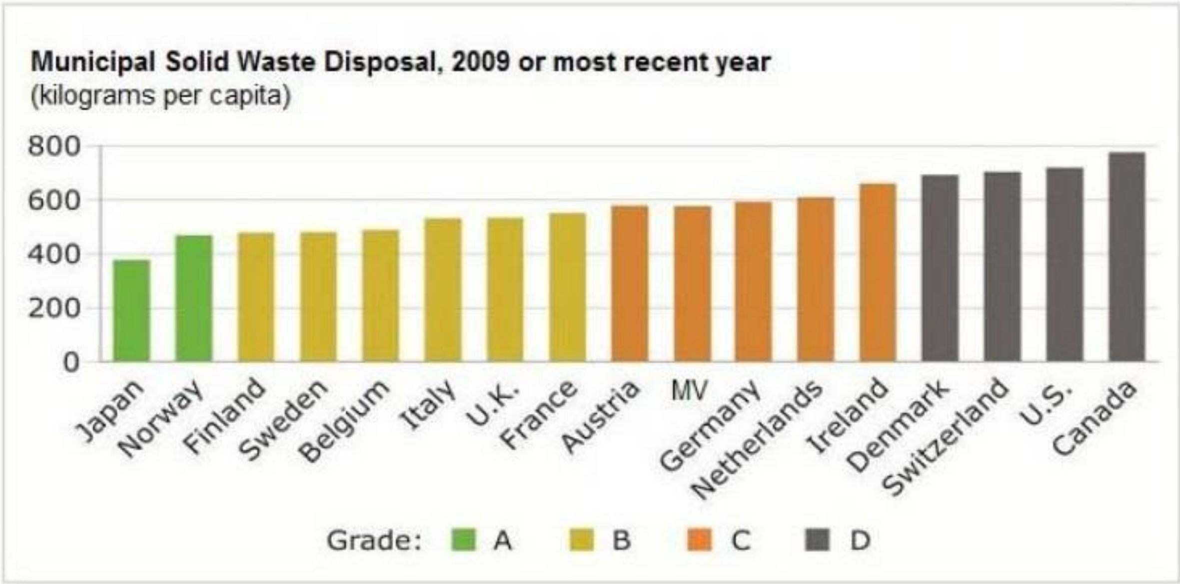

Figure 1.2: Per capita solid waste disposal in some developed countries

1.5 Indian scenario

1.5.1 Introduction

India is the second largest nation in the world, with a population of 1.21 billion (2011 census), accounting for nearly 18% of world's human population, but it does not have enough resources or adequate systems in place to treat its solid wastes. Its urban population grew at a rate of 31.8% during the last decade to 377 million, which is greater than the entire population of US, the third largest country in the world according to population. India is facing a sharp contrast between its increasing urban population and available services and resources. Solid waste management (SWM) is one such service where India has an enormous gap to fill. Proper municipal solid waste (MSW) disposal systems to address the burgeoning amount of wastes are absent. The current SWM services are inefficient, incur heavy expenditure and are so low as to be a potential threat to the public health and environmental quality. Improper solid waste management deteriorates public health, causes environmental pollution, accelerates natural resources degradation, causes climate change and greatly impacts the quality of life of citizens the present citizens of India are living in times of unprecedented economic growth, rising aspirations, and rapidly changing lifestyles, which will raise the expectations on public health and quality of life. Remediation and recovery of misused resources will also be expected. These expectations when not met might result in a low quality of life for the citizens. Pollution of whether air, water or land results in long-term reduction of productivity leading to a deterioration of economic condition of a country. Therefore, controlling pollution to reduce risk of poor health, to protect the natural environment and to contribute to our quality of life is a key component of sustainable development.

The per capita waste generation rate in India has increased from 0.44 kg/day in 2001 to 0.5 kg/day in 2011 Annepu.K.R (2012), fuelled by changing lifestyles and increased purchasing power of urban Indians. Urban population growth and increase in per capita waste generation

have resulted in a 50% increase in the waste generated by Indian cities within only a decade since 2001.There are 53 cities in India with a million plus population, which together generate 86,000 TPD (31.5 million tons per year) of MSW at a per capita waste generation rate of 500 grams/day. The total MSW generated in urban India is estimated to be 68.8 million tons per year (TPY) or 188,500 tons per day (TPD) of MSW Annepu.K.R (2012) Such a steep increase in waste generation within a decade has severed the stress on all available natural, infrastructural and budgetary resources.
Big cities collect about 70 - 90% of MSW generated, whereas smaller cities and towns collect less than 50% of waste generated. More than 91% of the MSW collected formally is landfilled on open lands and dumps Annepu.K.R (2012), It is estimated that about 2% of the uncollected wastes are burnt openly on the streets. About 10% of the collected MSW is openly burnt or is caught in landfill fires. Such open burning of MSW and landfill fires together releases 22,000 tons of pollutants into the lower atmosphere of Mumbai city every year. The pollutants include carbon monoxide (CO), carcinogenic hydro carbons (HC) (includes dioxins and furans), particulate matter (PM), nitrogen oxides (NOx) and sulfur dioxide (SO2).
Amount of recyclables collected by informal sector prior to formal collection are generally not accounted. This report estimates that 21% of recyclables collected formally are separated by the formal sector at transfer stations and dumps. Even though this number does not include amount of recycling prior to formal collection, it compares fairly well with the best recycling percentages achieved around the world. Informal recycling system is lately receiving its due recognition world-wide for its role in waste management in developing nations.

1.5.2 Present situation of SWM in INDIA

Solid waste management (SWM) is a basic public necessity and this service is provided by respective urban local bodies (ULBs) in India. SWM starts with the collection of solid wastes and ends with their disposal and/or beneficial use.. Most centralized municipal systems in low income countries like India collect solid wastes in a mixed form because source separate collection systems are non-existent. Indian cities are still struggling to achieve the collection of all MSW generated. Metros and other big cities in India collect between 70- 90% of MSW. Smaller cities and towns collect less than 50%. The benchmark for collection is 100%, which is one of the most important targets for ULBs at present. This is a reason why source separated collection is not yet in the radar.

1.5.3 Per capita MSW generation

Waste generation rate in Indian cities ranges between 200 - 870 grams/day, depending upon the region's lifestyle and the size of the city. The per capita waste generation is increasing by about 1.3% per year in India Cities in Western India were found to be generating the least amount of waste per person, only 440 grams/day, followed by East India (500 g/day), North India (520 g/day), and South India. Southern Indian cities generate 560 grams/day, the maximum waste generation per person. States with minimum and maximum per capita waste generation rates are Manipur (220 grams/day) and Goa (620 grams/day). Manipur is an Eastern state and Goa is Western and both are comparatively small states. Among bigger states, each person in Gujarat generates 395 g/day; followed by Orissa (400 g/day) and

Madhya Pradesh (400 grams/day). Among states generating large amounts of MSW per person are Tamil Nadu (630 g/day), Jammu & Kashmir (600 g/day) and Andhra Pradesh (570 g/day). Among Union Territories, Andaman and Nicobar Islands generate the highest (870 grams/day) per capita, while Lakshadweep Islands (340 grams/day) generates the least per capita. Per capita waste generation in Delhi, the biggest Union Territory is 650 g/day.

The Census of India classifies cities and towns into 4 classes, Class 1, Class 2, Class 3, and Class 4, depending upon their population (Table 4). Most of the cities studied during this research fell under Class 1. For the purpose of this study, these Class 1 cities were further categorized as Metropolitan, Class A, Class B, etc, until Class H depending upon the population of these cities. This finer classification allowed the author to observe the change in waste generation closer. However, the waste generation rates did not vary significantly between Class A, B, C, D, E, F, G & H cities. They fell in a narrow range of 0.43-0.49 kg/person/day. They generated significantly less MSW per person compared to the six metropolitan cities (0.6 kg/day). The per capita waste generation values of Class 2, 3 and 4 towns calculated in this report are not expected to represent respective classes due to the extremely small data set available. Data for only 6 out of 345 Class 2 cities, 4 out of 947 Class 3 cities and 1 out of 1,167 class 4 towns was available. Despite the lack of data in Class 2, 3, and 4 towns, the 366 cities and towns represent 70% of India's urban population and provide a fair estimation of the average per capita waste generation in Urban India (0.5 kg/day).

Table 1.2 Per Capita Waste Generation Rate depending upon the Population Size of Cities and Towns

Original Classification	Classification for this study	Population range(2001 census)		No. of cities	Per capita Kg/day
Class 1	Metropolitan	5,000,000	Above	6	0.605
	Class A	1,000,000	4,999,999	32	0.448
	Class B	700,000	999,999	20	0.464
	Class C	500,000	699,999	19	0.487
	Class D	400,000	499,999	19	0.448
	Class E	300,000	399,999	31	0.436
	Class F	200,000	299,999	58	0.427
	Class G	150,000	199,999	59	0.459
	Class H	100,000	149,999	111	0.445
Class 2		50,000	99,999	6	0.518
Class 3		20,000	49,999	4	0.434
Class 4		10,000	19,999	1	0.342

1.5.4 MSW generation

Generation of MSW has an obvious relation to the population of the area or city, due to which bigger cities generate more waste. The metropolitan area of Kolkata generates the largest amount of MSW (11,520 TPD or 4.2 million TPY) among Indian cities.

Among the four geographical regions in India, Northern India generates the highest amount of MSW (40,500 TPD or 14.8 million TPY), 30% of all MSW generated in India; and Eastern India (23,500 TPD or 8.6 million TPY) generates the least, only 17% of MSW generated in India. Among states, Maharashtra (22,200 TPD or 8.1 million TPY), West Bengal (15,500 TPD or 5.7 million TPY), Uttar Pradesh (13,000 TPD or 4.75 million TPY), Tamil Nadu (12,000 TPD or 4.3 million TPY) Andhra Pradesh (11,500 TPD or 4.15 million TPY) generate the highest amount of MSW. Among Union Territories, Delhi (11,500 TPD or 4.2 million TPY) generates the highest and Chandigarh (486 TPD or 177,400 TPY) generates the second highest amount of waste.

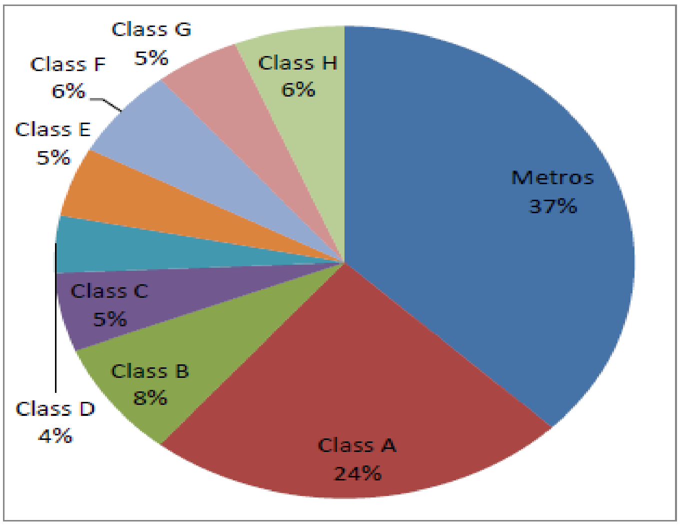

Figure 1.3 Shares of Different Classes of Cities in Urban MSW Generated

1.5.5 Composition of urban MSW in INDIA

A major fraction of urban MSW in India is organic matter (51%). Recyclables are 17.5 % of the MSW and the rest 31% is inert waste. The average calorific value of urban MSW is 7.3 MJ/kg (1,751 Kcal/kg) and the average moisture content is 47%. It has to be understood that this composition is at the dump and not the composition of the waste generated. The actual percentage of recyclables discarded as waste in India is unknown due to informal picking of waste which is generally not accounted. Accounting wastes collected informally will change the composition of MSW considerably and help estimating the total waste generated by communities

1.6 Objectives of project

The main objectives of the project are

1) Characterisation of leachate sample collected from solid waste dump site in Salogra, Solan.

2) Characterisation of groundwater sample collected from near the solid waste dump site in Salogra, Solan.

(3) Seasonal study of leachate, surface and groundwater quality in the vicinity of solid waste dump site.

(4) Characterization of soil in waste dumping site Salogra, Solan.

(5) Analysis of integrated sustainable waste management in city by using Benchmark indicators.

1.7 Organization of Report

I. Chapter 1 contains the description waste, type of waste, solid waste management system. This chapter also highlight the world and Indian scenario of waste production and management of solid waste.

II. Chapter 2 presents a brief review of the other related studies carried out at national and international level for find out the effect of solid waste dump site on environment.

III. Chapter 3 focuses on the research methodology that is followed for undertaking the present research work. This chapter also gives a brief description about the study area and different standard method used in testing during the research works.

IV. Chapter 4 presents the observations and discussion on the finding of the research work

V. Chapter 5 summarizes the conclusion drawn from the experimentation carried out in the present research work

Chapter -2

Review of Literature

Landfills are the major pollution causing source in the urban environments. The leachate generated from the landfills and open dumps pollute the ground water, soil and creates the health risks. The health risks are also associated with physical disturbances of landfill. Due to this landfills are most studied worldwide. The generation of leachate and the soil and ground water contamination is widely studied throughout the world.

Maity et.al., 2002 studied the ground water quality status of the waste disposal sites in the eastern part of Kolkata. They concluded that Chloride, Hardness and total dissolved solids in all the samples are significantly higher than the stipulated standard values.

Aluko et.al., 2003 have identified characteristics of leachates from municipal solid waste landfill sites in Inbadan, Nigeria. They reported the variation in the leachate quality during dry and wet season. They concluded that solid waste management has been a very serious problem in urban centers. Waste taken to a dumpsite for disposal yield leachate, which causes serious problem through contaminating the nearby land and water resource. And the developing countries like Nigeria have not been able to address these problems due to high costs involved.

Mor et.al., 2006 studied the leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site. They collected the leachate and groundwater samples from Gazipur landfill-site and its adjacent area in Delhi to study the possible leachate's impact percolation on groundwater quality. They reported the moderately high concentrations of chemicals in groundwater, likely indicate that groundwater quality is being significantly affected by leachate percolation. Influence of Municipal solid waste leachate on underground water was studied by Talalaj and Dzienis during 2007.

Esakku et.al., 2007 has carried out periodic monitoring of leachate quality at two large dumpsites in Chennai, India and four smaller dumpsites from Sri Lanka. They concluded that computation of leachate pollution potential and its variations with LPI can be used as a reliable evaluation method since they give similar trend as individual leachate quality parameters for seasonal and site specific variations.

Sabahi et.al., 2009 studied the compositions of landfill leachate and groundwater pollution at Ibb landfill, Yemen. They found that some bore wells were contaminated with landfill leachate, where the concentration of physico-chemical parameters is above the standard acceptable levels.

Goswami and Sarma, 2008 studied the impact of municipal solid waste dumping on the soil quality on Guwahati city. They noticed that the experimental values for the physicochemical parameters increased for the soils treated with solid waste in comparison to the control soil.

Raman and Narayanan, 2008 studied the solid waste effect on ground water and soil quality nearer to Pallavaram solid waste landfill site in Chennai and they found that the soil is contaminated with the solid waste material dumped in the area.

Khitoliyal et.al., 2009 studied ground water contamination by municipal solid waste landfill in the vicinity of Chandigarh and Panchkula Landfill sites. They found that the landfill leachate in these areas have contaminated the ground water and the depth analysis of the ground waters shows that the leachate contaminating them is having high organic content and heavy metal concentration. They also reported that the main reason of ground water pollution in these areas is due to the absence of Leachate and Landfill Gas Control Equipment.

Odukoya and Abimbole, 2010 carried out the assessment of contamination of groundwater around two solid waste dumpsites in Lagoos, Nigeria. They concluded that the water around most of the dumpsite areas exceeded the acute and chronic effect levels proposed by the United States Environmental Protection Agency in 2010.

Narayanan et. Al., 2008 carried out a study on Pallavaran solid waste dump site Chennai and collected the Soil and groundwater samples were collected to find out the possible impact of solid waste effect on soil and ground water quality. The physical and chemical parameters such as temperature, pH, hardness, electrical conductivity, total dissolved solids, total suspended solids, alkalinity, calcium, magnesium, chloride, nitrate, sulphate, phosphate and the metals like sodium, potassium, copper, manganese, lead, cadmium, chromium, nickel, palladium, antimony were studied using various analytical techniques. It has been found that most of the parameters of water are not in the acceptable limit in accordance with the IS 10500 Drinking Water Quality Standards. It is concluded that the contamination is due to the solid waste materials that are dumped in the area.

Pillai et. Al., 2014 studies on the Municipal Solid Waste disposal site for the city of Thrissur, in Kerala, India. To find out the Gas and leachate generation are inevitable consequences of practice of solid waste disposal in landfills. The migration of gas and leachate away from the landfill boundaries present serious environmental concerns which include, and are not limited to, fires and explosions, vegetation damage, unpleasant odour, landfill settlement, ground water pollution, soil pollution and global warming. Leachate and soil samples were collected from this landfill-site and its adjacent area to possible impact of leachate percolation on soil quality. Concentration of various physicochemical parameters and engineering properties were determined in soil samples. Conductivity and compaction characteristics of soil were studied. The study indicated that leachate can modify the soil properties and significantly alter the behaviour of soil. Effect of leachate on physicochemical and geo-engineering properties of soil were estimated by treating it with synthetic leachate. There is a general deterioration in soil properties which is attributed to the chemistry of leachate and of soil

Karthikeyan and Murugesan 2007 analyzed the various parameters like hardness, EC, alkalinity, chlorides, colour, odour and sulphates of the groundwater samples collected from dumping yard of Salem Municipal Corporation they reported that the hardness was about the prescribed limit of 300mg/L.

Jeyapriya and Saseetharan 2008 studied the characterization of Municipal solid waste and its leached liquid were was carried out, which not only forms a key for an efficient solid waste management system and to assess potentially of impairing the ecosystems but also provide information about the rate and extent of decomposition of dumped waste

Venketa.G et. Al., 2014 collected leachate and groundwater samples from municipal solid waste dumpsite of Mavallipura, Bruhat Bangalore Mahanagara Palike Bangalore. After Characterization of various physico chemical parameters for selected ground water and leachate samples . they have been observed that, in the ground water the concentrations of various parameters such as Ca2+, Mg2+, NO3-, TDS, TA are on the higher side than the prescribed limits. The result shows that the leachate analyzed for various parameters are also on the higher side. This study reveals that the most of the parameters are exceeding their acceptable limit and hence significant impact on the surrounding soil and ground water quality.

Roseta et. Al., 2012 carried out a study in Owerri municipal, the regional capital of Imo State to characterize the heavy metal content and physicochemical properties of waste dump sites for more than 15 years. During the study Soil samples were collected from two different locations with control samples collected ten meters away from the dumpsites. The samples were collected at different depths from each of the sites. And analyses for properties such as heavy metals (Ld, Fe, cu), chemical properties (organic carbon and Nitrogen pH CEC and EA) and physical properties. Results reveal that the wastes dump sites showed variability in soil properties with depth the soils of the non-dump site at varying depth are classified as slightly acidic of high aggregate stability (76%). They also found that Heavy metal content were generally higher at deeper depths and the hill top waste dump site had higher values compared to the gulley dump site only at shallow depth.

Christopher et. Al., 2015 Carried a work on landfill at Akure, Nigeria was carried out to find to the effects of dumpsite pollution on groundwater quality. In their work water samples was collected from Borehole located at different distances. The different physical and chemical parameters like turbidity, temperature, pH, Dissolved oxygen (DO), total dissolved solids (TDS), Total Hardness, Total Iron, Nitrate, Nitrite, Chloride, Calcium and heavy metals such as Copper, Zinc and Lead were analysed during the research. The results revealed that Most of these parameters indicated traceable pollution but were below the World Health Organization (WHO) and the national Standard for Drinking water quality (NSDWQ) limits for consumption. The results showed that all but one of the boreholes was strongly polluted but require urgently certain levels of treatment before use. Public enlightenment on waste sorting, adoption of clean technology, using climate change mitigation strategies and the use of sanitary landfill to prevent further contamination of ground water flow are recommended.

Maili et. al., 2015 carried out a research in Dhapa solid waste dump site Kolkata. During the research leachate sample were collected and analysed for different parameters in two season The laboratory test results show prevalence of high concentration of TDS, NH_4^+-N (4210 mg/L), Cl^- and some heavy metals such as Pb and Hg in all the leachate samples. The maximum concentration of heavy metals lead and mercury are found to be 0.53 mg/L and 0.66 mg/L respectively for water resources, which has exceeded their respective permissible limits recommended by Bureau of Indian Standards (BIS). The results recommend appropriate leachate treatment before discharging it to the surrounding environment.

Ghosh et. al., 2015 carried out a work in Delhi landfill sites collected leachate samples from three landfill sites. All samples toxico-chemically analyzed for human risk assessment. During the stud leachate samples were collected from the municipal solid waste landfills of lacking liner systems. Results reveals that all the samples have relatively low concentrations of heavy metals while the organic component exceeded the upper permissible limit. Qualitative analysis showed the presence of numerous xenobiotics belonging to the group of halogenated aliphatic and aromatic compounds, polycyclic aromatic hydrocarbons (PAHs), phthalate esters, and other emerging contaminants.

Pamnani et. al., 2014 presented a brief overview of MSWM in Major cities medium scale towns and small-scale towns. The research work also presented some interesting results on MSWM of small-scale towns and their surrounding villages And impact of the solid waste of environment and human health.

Gautam et. al., 2010 Carried out a research at Sewapura MSW dumpsite near jaipur to assess the ground water quality in and around the study area. The results of their work reveal that high concentration of Fluoride (2.4 - 3.2 mg/l). Chlorides (288.4 – 1038.2 mg/l) and TDS (610.4 – 1828.4 mg/l). All the parameters exceeding the permissible limits. All the results of their study reveal the percolation of toxic elements from the solid waste and polluted the groundwater resources.

Oyeku and eludoy 2010 collected the 20 random samples from borehole around the solid waste dump sites in Nigeria. And 10 leachates samples were also collected from the dumpsite. From these samples, pH and conductivity were determined using a pH/conductivity meter, while the concentrations of the heavy metals (Co, Fe, Pb and Cu) were determined using atomic absorption spectrophotometer (AAS). The trend of dispersion of each variable was demonstrated on Landsat ETM+ (2006) imagery using Erdas Imagine and ArcView GIS software. The study showed that the groundwater in the study area were alkaline and contained Cu, Fe, Pb and Co concentrations that are higher than the permissible limits recommended by the World Health Organization. The study concluded that the groundwater sources within 2 km radius of a major landfill will be vulnerable to the effect of landfill, if they are not adequately protected.

Salami el. al., 2014 Assessed a research on OkeAfa dumpsite to find out its impact on surface and groundwater quality in the vicinity of the dumpsite. Soil samples were also collected from different locations on the dumpsite at the surface, at the different depth. Five different groundwater samples were collected at various radial distances from the dumpsite and five different surface water samples along the dumpsite were collected. All the samples were examined for zinc, lead, nickel, copper, chromium, iron, magnesium, calcium, manganese, sodium and potassium as well as biochemical oxygen demand and chemical oxygen demand in the case of ground and surface water. The results showed that closed dumpsite has no serious impact on the ground and surface water quality. It also revealed the concentrations of parameters analysed did not follow a particular tread. The results of the groundwater samples fall within the guideline for drinking water by World Health Organisation and National Agency for Food and Drug Administration and Control but there was a scarcity of guideline for soil of closed dumpsites for the purpose of comparison.

Dharmarathne and Gunatilake 2013 carried a research to find out the effect of landfill leachate on groundwater quality at Gohagoda landfill site, which is located at north-west of Kandy city. The Leachate sampled at nine different locations of the landfill. Groundwater samples were collected at five locations For different two wet and dry seasons. Leachate and groundwater were physically and chemically characterized. Parameters measured were pH, Sulphate, Nitrate, Nitrites, Heavy metals. The results of this work revealed that leachate of the landfill were most likely methanogenic phase, based on the alkaline pH value recorded. These results also showed that significant number of borehole were contaminated where concentration of physio-chemical parameters are above the W.H.O standards required for drinking water. Therefore, this landfill is a threat for the environment, and government should do sanitary landfill to prevent further contamination of groundwater as well as soil.

Muhammad and Zhonghua 2014 investigated the landfills effects on groundwater system in Lahore city, Pakistan. Sixteen points were selected for groundwater sampling in the target area and all samples were analyzed for twelve parameters. Samples were collected to at different distance from three dumping sites and found in mostly samples contains high pollutants concentration than Standards and Quality Control Authority and arsenic concentration over World Health Organization (WHO) drinking water criteria. Dumping sites impacts are in result of changing groundwater chemistry, waterborne diseases and other environmental problems.

Sunita and Saharan 2009 Ground water samples were collected from different locations in the radius of 25 km. of Kaithal city, Haryana(India). These water samples from 20 sampling points of Kaithal were analyzed for their physicochemical characteristics. Laboratory tests were performed for the analysis of samples for pH, Colour, Odour, Hardness, Chloride, Alkalinity, TDS etc. On comparing the results against drinking water quality standards laid by Indian Council of Medical Research (ICMR) and World Health Organization (WHO), it is found that some of the water samples are non-potable for human being due to high concentration of one or the other parameter. The usefulness of these parameters in predicting ground water quality characteristics were discussed. Thus an attempt has been made to find the quality of ground water in and around Kaithal City town, suitable for drinking purposes or not.

Abd El-Salam and Abu-Zuid 2015 carried out a research to evaluate the environmental impacts associated with solid waste landfilling, leachate and groundwater quality near the landfills were analyzed. The results of research of physico-chemical analyses of leachate confirmed that its characteristics were highly variable with severe contamination of organics, salts and heavy metals. The BOD5/COD ratio (0.69) indicated that the leachate was biodegradable and un-stabilized. It was also found that groundwater in the vicinity of the landfills did not have much more contamination, although certain parameters exceeded the WHO and EPA limits. These parameters included conductivity, total dissolved solids, chlorides, sulfates, Mn and Fe.

Chavan and Zambare 2014 carried a research works on Municipal Solid Waste (MSW) dumping site, solapur, maharashtra, India during the research water samples were collected in the study area during pre- monsoon and post- monsoon season and all the samples were analyzed for different parameters likes pH, Turbidity, Hardness, Total Dissolved Solids, fluoride, Chloride, Sulphate, Nitrate, MPN etc. The results of all water samples for both seasons show that the ground water is not fit for direct use particularly in post monsoon season due to high bacterial contamination that may result in many waterborne diseases and other environmental problems.

Olusanya, 2013 collected the water sample from two major dumpsite in logos Nigeria. To find out the impact of solid waste dump site on groundwater. and Findings of the work revealed that there is the sufficient bacteriological contamination in the sample collected from the dumpsites and not fit for the direct consumption. They suggested that water should be treated before the use.

Abdullah el. al., 2012 carried a research to find out the impact of Municipal solid waste dumping on groundwater quality at Beed, Maharashtra. The study revealed that MSW dumping has clearly deteriorated the quality of the groundwater. A number physicochemical parameters were selected include pH, Dissolved Oxygen (DO), Alkalinity, Salinity, Chlorides, Nitrates, Calcium Hardness, Magnesium Hardness, Total Hardness(TH), Sulphates and Biological Oxygen Demand (BOD) to find out the effect of dump site on groundwater quality.

Shahid et. al., 2014 worked in Karachi city Pakistan and collected the different data like solid generation, composition of municipal solid waste (MSW) to find out the impact of solid waste dump site on the ground water . during the research work Samples were collected according to the spot sampling method of municipal solid waste as well as groundwater and all the samples analysis for physical and chemical parameters, such as, pH, TDS, Moisture Content, Total Hardness, Calcium (Ca), Magnesium (Mg), COD, Sodium (Na), Phosphorous (PO4), Potassium (K) and the metals like Lead (Pb), Cadmium (Cd), Chromium (Cr) and Nickel (Ni) using analytical techniques. It has been found that most of the parameters of municipal solid waste and ground waste are beyond the permissible limits in accordance with the Pakistani Standards as well as Indian Standards. It is concluded that the contamination is due to the solid waste material that are dumped at the landfill site.

Musa 2014 carried a study in kubuwa, Nigeria and collected Ground water samples in and around dumpsite and landfills to assess the effect of wastewater leachates on groundwater resources in the particular area. Groundwater samples were collected from 5 different bore-wells in and around relative distances from dumpsites. He found EC values between 30 and

138 μS/cm, TDS r between 95 mg/L and 120 mg/L, SS ranged between 10 and 23 mg/L while that of the range of between 11 and 15 mg/L, nitrate values in between 0.18 to 0.80 mg/L for the early morning samples while the late evening samples which ranged between 0.25 and 0.43mg/L, while concentration of Sulphate in the morning water sample ranged between 168 and 213 mg/L while that of the evening ranged between 20 and 45 mg/L

Longe and Balogun 2009 worked to examining the level of groundwater contamination near a municipal landfill site in Alimosho Area of Lagos State, Nigeria. Water quality parameters like physico-chemical and heavy metals of leachate and groundwater samples were analyzed during the study. And results that concentrations of all measured parameters except one or two were higher World Health Organization potable water standards and the Nigerian Standard for Drinking Water Quality. Study show insignificant impact of the landfill process on the groundwater resource. The present soil stratigraphy at the landfill site consisting of clay and silty clay was deduced to have visible influenced natural attenuation of leachate into the groundwater resource. It was also observed that in the absence of a properly designed leachate collection system, uncontrolled accumulation of leachate at the base of the landfill pose potential contamination risk to groundwater resource in the very near future. They recommends an upgrade of the solous landfill to a standard that would ensure adequate protection of both the surface and the groundwater resources in the locality.

Bundela el. al., 2012 study in Jabalpur dumpsite, India to find out the effect of uncontrolled dumping of Municipal Solid Waste on groundwater quality. And ten groundwater samples collected during the rainy season 2011 from the target region and t analyzed for various physical and chemical properties. They found that Infiltration of water by rainfall, water content in the waste, or water generated by biodegradation, cause the leachate to leave the dumping ground laterally or vertically and find its way into the groundwater thereby causing contamination. During the study it was found that Total Dissolved Solids varies from 546 mg/L to 907 mg/L and compared with permissible limits. They suggest the best accepted option is to avoid the possibility of polluting the groundwater resources.

Patil el. al., 2013 collected water sample from seven bore wells located around landfill site at Turmuri, Belgaum for analysed the Physical, chemical and bacteriological analyses to find out the effect of dumpsite pollution on groundwater quality. During this work, seven bore wells were selected around the landfill area at different distance. And parameters analyzed in the research were pH, total dissolved solids (TDS), Total Hardness, Nitrate, Most Probable Number (MPN) and heavy metal such as Lead using standard laboratory procedures. The reveal that pH ranged from 6.01 to 7.3 indicating acidic in nature the three bore wells about 500m radius of landfill . Hardness, TDS, Nitrate and MPN values were in the range from 0 to 80 mg/L, 49 to 190 mg/L, 4 to 79.89 mg/L and >1600/100ml respectively. The research reveal that within 500 m bore wells were contaminated by E-Coli bacteria, also nitrate concentration is above the permissible level described by WHO for portable water and pH were acidic in nature. The polluted water requires certain levels of treatment before use. Public enlightenment on waste sorting, adoption of clean technology, using climate change mitigation strategies and the use of sanitary landfill to prevent further contamination of ground water flow are recommended.

Kamboj and Choudhary 2013 carried out a study was carried out to find out impact of domestic wastes disposal on ground water quality at Delhi, India. For this purpose ground water samples were collected and analyzed for various physico-chemical parameters like alkalinity,conductivity, total dissolved solids (TDS), total hardness, calcium, magnesium, chloride, sulphate, nitrate, phosphate, fluoride, sodium and potassium. And they found the higher concentration of TDS TDS that were beyond the desirable limits of BIS at all the sampling sites. Maximum value of TDS was found 2061 mg/l. Chloride (560 mg/l) was also high and rest all other parameters were found within permissible limit of BIS. The study concluded that the chloride and TDS in water samples were above to the desirable limit and below to the permissible limit of BIS and rest all other parameters were within desirable limit.

Singh et. al., 2012 works on the Groundwater Contamination Hazard Rating Model for municipal solid waste dumps and landfills developed to prioritise remedial measures at uncontrolled sites. The model is based on the source-pathway-receptors hazard chain. Source is the candidate landfill or waste dump, and is described by a number of parameters like landfill size, waste composition, landfill operating practices, and annual precipitation. Pathway is the medium for transport of the contaminants from the source to the receptors and is characterized by a number of parameters dealing with the leachate containment system, the vadose zone and the aquifer.

The receptor is the groundwater and the users thereof in the vicinity of the source including the human population, crops, livestock and wildlife. Various model parameters dealing with source, pathway and receptors have been identified based on literature and expert opinion. The relative importance weights of various category parameters are derived using the Delphi technique. The source, pathway and receptor parameters are aggregated separately by using a combination of the multiplicative-additive algorithm and the fuzzy composite programming. A final score between 0 and 100, which is arrived at by combining source, pathway and receptor scores into one value, indicates the groundwater contamination hazard rating of a waste dump or landfill at any point in time during its entire leaching life.

The hazard rating model presented here can be applied while the landfill is still in operation or after the landfill is closed. It can predict the peak value of the groundwater contamination hazard that a proposed landfill will have at some point in time during its leaching life, which can be used as important information for site selection, planning and designing of new landfills. The model has been applied on two waste dumps of different sizes in the city of Delhi, India. One of these waste dumps is still active while the other one has been closed. The results of the present model have been compared with those of two existing models. The comparison shows that the present model responds better to varied site conditions as compared to the existing models. A sensitivity analysis performed on key model parameters, using data of one of these two waste dumps, shows that the hazard score varies significantly with change in these parameters.

Laniyan et.al., 2013 evaluated the geochemical implication of Heavy metals on the groundwater surrounding a municipal solid waste dumpsite at Olusosun, waste disposal site

Lagos. In this study they collected Twenty groundwater samples and a leachate around the dump site and the samples were preserved by two drops of concentrated nitric acid before it was sent for analysis. The results revealed high concentration of Pb, Fe and, Mn when compared with WHO, while all the metals were found high concentration in the leachates. Contamination assessment revealed Fe and Pb to be contaminated in the groundwater, while geoaccumulation factor showed that farther away from the dumpsite contamination reduces. Pb, Mn, Fe are found to be from anthropogenic source and correlated significantly Pb-Cd (0.84), Mn-Pb (0.90), Fe-Cd (0.76) with each other.

Agrawal et. al., 2013 carried out a research on MSW dumps to find out impact of the leachate on groundwater . during the study an attempt has been made to investigate the extent of impact on ground water sources namely open wells, shallow tube wells (depth less than 30 m) and deep tube wells (depth more than 50 m). The pollution status is also monitored at varying distances from the solid waste dumping sites to investigate the trend of leachate movement in the subsoil. Water samples from different sources at different locations are assessed for physical, chemical and biological properties. The results revealed that the dumpsite have the sufficient effect on the quality of ground water.

Chapter 3

Material and Methods

3.1 Study area

Solan is one of the south-western districts of Himachal Pradesh having geographical area of 1,936 sq km. The district lies between North latitude 30°44’53” to 31°22’01” and East longitude 76°36’10” to 77°15’14” and is covered by Survey of India degree-sheets 53A, 53B, 53E and 53F. The population of the district is 5,76,670 (2011 census), of which 2,70,291 (54 %) males, 2,30,266 (46 %) female, sex ratio (F:M) is 852:1000 and density of population is 300 per sq km.

3.1.1 Climate & rainfall

The climate of the area is sub-tropical in the valley and tends to be temperate in the hilltops. There are four major seasons. The winter season commences from Nov to Feb & ends in march; summer season extends from March to June followed by the monsoon period extending from July to September. Maximum precipitation occurs during the months from July to September. Average annual rainfall in the district is about 1450 mm with average of 64 rainy days. In the winter season precipitation as snowfall also occurs in the higher reaches upto 1000 m elevation and as rainfall in low hills and valleys of the district. Mean maximum and minimum temperature ranges between 34°C and 4°C

Figure 3.1.1 Map of Solan district from where waste is collected

3.1.2 Geomorphology & soils

The study area presents in tricate mosaic of high mountain ranges, hills and valleys with altitude ranging from 300 to 3000 m above MSL. The altitude of the hill ranges is higher in northern parts whereas south-western part of the district is represented by low denuded hill ranges of Siwalik. In the areas underlain by high hill ranges of Himalayas, the valleys are narrow and deep with steep slopes trending in NW-SE direction. The terrain is moderately to highly dissected with steep slopes. The study area is drained by streams/rivers forming part of the drainage basins of the Sutluj, the Yamuna and the Ghaggar rivers. However, major part of the district is drained by tributaries of Sutluj river viz., Ghambar river and Sirsa nadi. Ghambar River flows almost from the central part of the district towards north 12 towards north-west in the Nalagarh valley. The Giri River and its tributary Assan, flows towards south in the eastern part over a small area and are part of Yamuna river basin. Most of the rivers/streams/khads maintain base flow for major part of the year. In hilly terrain the drainage density is high and fine but it become coarse in foothill, kandi areas and valleys. Soil is generally sandy loam in valley areas of the district and in rest of the hilly and mountainous areas soil is skeletal, soil depth is generally shallow except in areas having good vegetative cover. It is generally dry, shallow and deficient in organic matter. Landslides are the common features in mountainous terrain. Soils are rich in nutrients and thus are fertile-east to join Sutluj river in the Gobind sagar lake. Another important-tributary of Sutluj river is the Sirsa Nadi flowing

3.2 Brief information about Solid waste management at site Salogra (District Solan, HP)

Municipal Corporation (MC) Solan has a well organised network of solid waste collection & disposal. Waste is collected from 132 collection points with the help of 115 sanitation workers. Out of these 132 collection points, as many as 42 are the dumpers. The council has 2 placers and 1 tipper which are privately hired. It has 4 drivers. A total of 10 tons of solid waste is collected every day and transported to the waste recycling plant at Salogra. The plant is fully capable of meeting with the requirements of the town. The waste recycling plant situated at Salogra is a unique thing in itself. Firstly it's only at Shimla and Solan that we have the waste recycling plants in Himachal Pradesh. The plant has land and processing plant capable of handling a total of up to 22 tons of solid waste. Presently on an average, up to 10 tons of waste arrives here. On festival days the quantum reaches up to 13 tons. As and when a dumper placer or a tipper arrives from a unit, the constituents are segregated by the workers into polythene, stone, medical waste, paper, kitchen waste & such categories. Paper is recycled in the paper recycling plant. The organic waste is kept in open heaps which decompose in a period of 40–45 days reducing it to compost. The other part of the waste being sanitary in nature is dumped on open land. There are a number of facilities here. There is a JCB, a plant processor, soil testing & compost testing lab and an office.

3.2.1 Waste composition and generation

The composition of waste of Solan district is obtained as a percentage of different constituents is given in the Table 1 (Personal communication with the employee of the dumping site, management of urban solid waste of Solan). It was found that a major fraction of municipal solid waste consists of high organic matter, recyclables and inert waste. The moisture content ranges from 40-70% (Sharholy et al, 2009). The actual percentage of recyclables discarded as waste is unknown due to informal picking of waste which is generally not accounted. Some of the future challenges for the management of solid waste are increasing quantities and changing composition, increasing severity of adverse impacts increasing the cost of waste management, limited policy framework and lack of political priority. The quantity of municipal solid waste generated depends upon number of factors such as food habits, standard of living, degree of commercial activities and seasons. With increasing urbanization and changing lifestyles, Indian cities generate eight times more waste than they did in 1947 (Kumar et al, 2009). Presently about 90 million tons of solid waste are generated annually as by products of industrial, mining, municipal, agricultural and other processes. The composition and quantity of solid waste generated form the basis on which the management system needs to be planned, designed and operated.

Table 3.2.1 Composition of municipal solid waste in Solan

S.No	Components	Percentage (%)
1.	Metal	0.9
2.	Glass/Ceramics	1.70
3.	Food & Carbon Waste	26.0
4.	Paper & Cardboard	18.10
5.	Textile	6.80
6.	Plastic	14.50
7.	Rubber/Leather	4.80
8.	Inert	11.40
9.	Misc. Combustible	4.80
10.	Misc. Non-Combustible	11.0

Total waste generation rate of waste in Solan district is 22.5 ton per day and average per capita waste generation is 300 gms/capita. Table 2 shows the area wise total population, per capita waste generation and total waste generation of Solan district.

Table 3.2.2 Waste generation scenario in Solan district

Region	In 2015 Total population	Waste/capita (gms)	Total waste (TPD)
MC area Solan	40,000 and floating population 15000	350	15
Panchayatsamiti, Rabon, Basal and Salogra	5000	200	1
Vegetable mandi	NA		1 avg.
Dhrampur,Solan	8,000	350	3
Panchayat,Kandaghat, Kyarighat	7000	200	1.5
Waknaghat and kaithlighat	2000	200	0.5 avg.

3.2.2 Waste Collection and transportation

Many studies on urban environment have revealed that the municipal solid waste collection efficiency is a function of two major factors i.e. manpower availability and transport capacity (Kumar et al, 2009; Sharholy et al, 2009)**.** MC Solan has a good organised network of solid waste collection & disposal. Waste is collected from 132 collection points with the help of 115 sanitation workers. Out of these 132 collection points, as many as 42 are the dumpers. But there is no provision of door to door collection of waste. The waste collecting bins or containers are placed at places nearby to the residential and commercial areas. People dispose of their waste into these containers.

There is not a provision of door to door waste collection. The municipal corporation of the Solan district should make provision for door to door waste collection services and bins should be placed at more places so as to avoid any unsanitary and unhealthy conditions. Waste is littered on the roads as well as streets which is not only spoiling the aesthetic beauty of the place but also is degrading the environment. Due to less availability of the bins people are throwing waste outside the overflowing bins. The municipal corporation of Solan district has collaborated with the many private companies for increasing the efficiency of collection of waste and majorly paying attention towards door to door collection of municipal solid waste. With the augmentation of doorstep collection services, the municipal corporation of Solan district could achieve in making container free areas by reducing more containers and compact buckets.

Removal of garbage is a very important aspect of solid waste management and method of transportation is vital. Transportation implies conveyance from point of collection to the point of final disposal either directly or through the transfer system. In Solan district, waste is collected from the bins placed at the nearby places and then transported to the disposal site. For transportation purposes the municipal corporation of Solan has 2 placers and 1 tipper which is privately hired. It has 4 drivers and also has collaboration with a few private agencies for providing the vehicles. The trucks used for transportation of municipal solid waste are generally open body type and usually kept uncovered thus during transportation the waste tends to spill on the road resulting in unhygienic conditions. Transfer stations are not used, and the same vehicle which collects the refuse from the dustbins, takes it to the disposal site.

Table 3.2.3 Waste transportation system in Salogra solid waste management plant (Solan)

S.NO.	TRANSPORTATION	DETAILS
1.	Truck –Tipper	2
2.	Tractor-Trailor	NO
3.	Refuse-Collector	NO
4.	Dumper- Placer	1 no. and 2 no.
5.	Animal- cart	NO
6.	Tricycle	3 no.
7.	Others	NO

Collection and transportation activities constitute approximately 80-95% of the total budget of the municipal solid waste management hence it forms a key component in determining the economics of the entire municipal solid waste management system (Rana et al., 2014 and Rana Pratap et al., 2014) and as such the Solan municipal corporation should use a better and efficient waste transportation systems.

3.2.3. Waste storage and Processing

The total available land area for storing and disposing the waste is 3 acre. Processing of waste help in achieving the best possible benefit from every functional element of the solid waste management. Processing involves separation, composting, recycling of waste recovery. The waste coming is the mixed form and no segregation machines are available in this plant. Waste is separated by hands. The segregation of waste at source and promotion of recycling or reuse of segregated materials reduce the quantity of waste and burden on landfills and also provide raw materials for manufacturers. Plastic, glass, clothes and other non biodegradable materials are separated. Treatability for the processing of solid waste depends on the physico-chemical characteristics of the waste. Due to nutrient value of organic matter, percentage of biodegradable component in municipal solid waste is the most important influencing factor in treatability.

a) Composting:

Biodegradable waste converts into compost. The compost plant is based on the concept of open windrow aerobic composting of organic (biodegradable) component of solid waste. About 18 ton waste goes to composting plant daily. All activities associated with composting operations need careful selection of design and control to produce good quality product while minimizing environmental impacts

Figure 3.2.1 Final compost after composting process

Produced compost sell to the farmers of Himachal Pradesh and getting the benefit of organic manure for the agriculture produced.

b) Recycling Unit:

In the recycling complex the segregated recyclable waste processed to produce value added products. Paper, Cloths, Metals, and Rubber bailed and sold to authorize dealers. Currently plant have started sending the plastic waste to Ambuja cement industry

3.2.4. Waste Disposal

Disposal is the ultimate fate of solid waste. Disposal is the most important element because if waste disposal is not proper it will pollute the land, water and air ultimately lead to degradation of environment. Disposal should be in proper scientific manners for avoiding environmental and health hazards. Disposal includes open dump, incineration, and sanitary land fillings .To dispose waste in efficient way technology knowledge, trained manpower, appropriate infrastructure and availability of land is required.

In Salogra, waste management site waste is disposed in open dump which was set up in the year 1998. Figure 3 and shows the dumping site. The municipal solid waste coming to the dump is disposed off openly. There is on liner system provided to dump site. The progress in moving towards sanitary landfills and/or disposing through well designed and well operated incinerators is rather slow mixed comes to the site which is then dumped in the site as it is without giving any treatment. It is a non-engineered site where no prior efforts have been made to ensure environmental protection.

Figure 3.2.2 Map of Solid waste dump site, Salogra (Solan)

Figure 3.2.3 Solid waste dump site, Salogra (Solan)

3.3 Methodology

3.3.1 Sampling

Leachate Sample has been collected from waste dump site. Groundwater water sample has also been taken from the hand pumps near the waste disposal sites and surface water sample also collected. Soil sample has also collected for analysis the effect on soil in areas of interest. All the samples are collected for two different season. Sample for bacteriological parameters collected in sterilised bottle. Sample for the heavy metals was preserved according to IS: 3025 (part -1). pH of the samples were also measured to site with the help of pH strip.

Experimental investigations will performed as per APHA 22nd Edition 2012 for analyses of pH, Turbidity, Total Dissolve Solid (TDS), Chloride, nitrate, sulphate, trace metals, bacteriological parameters, BOD, COD

Figure 3.3.1 Sampling bottles and sterilized bottles

3.3.2 Parameters to be tested

The various water quality parameters were studied and their tests will be carried out. Experimental investigations were performed as per APHA 2005 for analyses of pH, Total Dissolve Solid (TDS), sulphates, BOD, COD, bacteriological test, ammonical nitrogen, turbidity, EC, trace metals.

1) pH (APHA 22nd Edn.2540-H+B)

It is expressed as the logarithm of the reciprocal of the hydrogen ion concentration in moles/litre at a given temperature. While the alkalinity or acidity measures the total resistance to the pH change or buffering capacity, the pH gives the hydrogen ion activity. The pH meter must be calibrated before making pH measurements. For calibration standard buffers of pH 4.00, 7.00 and 10.00 are used. pH of water indicates the hydrogen ion concentration in water.

Figure 3.3.2 Digital pH meter

2) Turbidity (APHA 22nd Edn. 2130B):

Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light: the higher the intensity of scattered light, the higher the turbidity. The turbidity of sample solution can be measured by using Nephelometer. It is usually measured in Nephelometric turbidity units (NTU) or Jackson turbidity units (JTU).

Figure 3.3.3 Nephelometer

3) Electrical conductivity (APHA 22nd Edn. 2510B):

Electrical conductivity (EC) is a measure of how conductive the water is to electrical current. Greater the ion concentration, greater is the EC. Generally higher the EC, higher is the total dissolved solids. Electrical Conductivity is an indirect measure for finding the total dissolved solids in a water body. To convert the electrical conductivity of a water sample (micro Siemens per cm, µS/cm) to the concentration of total dissolved solids (ppm), the conductivity must be multiplied by a factor between 0.46 and 0.9 (depending on the unique mixture of the dissolved materials). A widely accepted conversion factor is 0.67. TDS (ppm) = Conductivity {(µS/cm) x 0.67}.The instrument used for measuring conductivity is conductivity meter

Figure 3.3.4 Conductivity meter

4) TDS (total dissolve solids) APHA 22nd Edn.2540-D:

TDS refers to total amount of total dissolved solids in a water samples. TDS in water supplies originate from natural sources, sewage, urban and agricultural run-off, and industrial waste. Certain components of TDS, such as chlorides, sulphates, magnesium, calcium, and carbonates, affect corrosion and may also cause health problem. The Bureau of Indian Standards (BIS) fixes the upper limit of TDS in drinking water at 500 ppm. Crucially the standard also mentions that in case no alternative source of drinking water is available, then this upper limit can be relaxed to 2,000 ppm.

5) Sulphate (APHA 22nd Edn. 4500 So_4 C):

The sulphate ion is one of the major anions occurring in natural waters. It is of importance in public water supplies because of its cathartic effects. Sulphate may determine by gravimetric method. According to this method sulphate is precipitated in a hydrochloric acid (HCl) solution as barium sulphate by addition of barium chloride. The precipitate was carried out near the boiling temperature, after a period of digestion the precipitate was filtered washed with water until free of Cl, ignited or dried and weighted as $BaSO_4$

6) BOD (IS: 3025 (Part 44)-1993, Reaffirmed May, 2009)

The amount of oxygen required by aerobic microorganisms to decompose the organic matter in a sample of water, such as that polluted by sewage. It is used as a measure of the degree of water pollution also called biological oxygen demand. A measure of the organic pollution of water: the amount of oxygen, in mg per litre of water, absorbed by a sample kept at 20°C for five days and 27^0C. Winkler procedure with the azide modification.

Figure 3.3.5 BOD incubator and BOD bottles

Figure 3.3.6 Titration for BOD test

7) COD (APHA 22nd Edn. 5220-B):

The standard method for indirect measurement of the amount of pollutant (that cannot be oxidized biologically) in a given sample of water. The chemical oxygen demand test procedure is based on the chemical decomposition of organic and inorganic contaminants, dissolved or suspended in water. The result of a chemical oxygen demand test indicates the amount of water-dissolved oxygen (expressed as parts per million or milligrams per litre of water) consumed by the contaminants, during two hours of decomposition from a solution of boiling potassium dichromate. The higher the chemical oxygen demand, the higher the amount of pollution in the test sample. For the contaminants that can be oxidized biologically, the biological oxygen demand (BOD) method is used.

Figure 3.3.7 COD digester

8) Ammonical nitrogen determination (APHA 22nd Edn. 4500 NH_3 C)

Colorimetric method: The addition of Nessler reagent to a sample of distillate will produce a colour which ranges from pale yellow to brown depending upon the amount of ammonia present. The wavelength at which the measurement is made is dependent on the concentration level expected.

Figure 3.3.8 Spectrophotometer

9) Total Kjeldahl Nitrogen (TKN) (APHA 22nd Edn. 4500 B+C)

It is an analysis to determine both the organic nitrogen and the ammonia nitrogen. The analysis involves a preliminary digestion to convert the organic nitrogen to ammonia, then distillation of the total ammonia into an acid absorbing solution and determination of the ammonia by an appropriate method.

Figure 3.3.9 Kjeldahl apparatus for total nitrogen

10) Heavy metals (APHA 22nd Edn. 3111 B):

Generally heavy metal is not found in nature ground water but due many anthropogenic activities heavy metals may leached into groundwater and pollutes it. The presence of heavy metals is very dangerous to human consumption. The concentration of heavy metals in water sample is determined with the help of instruments like AAS and ICPMS.

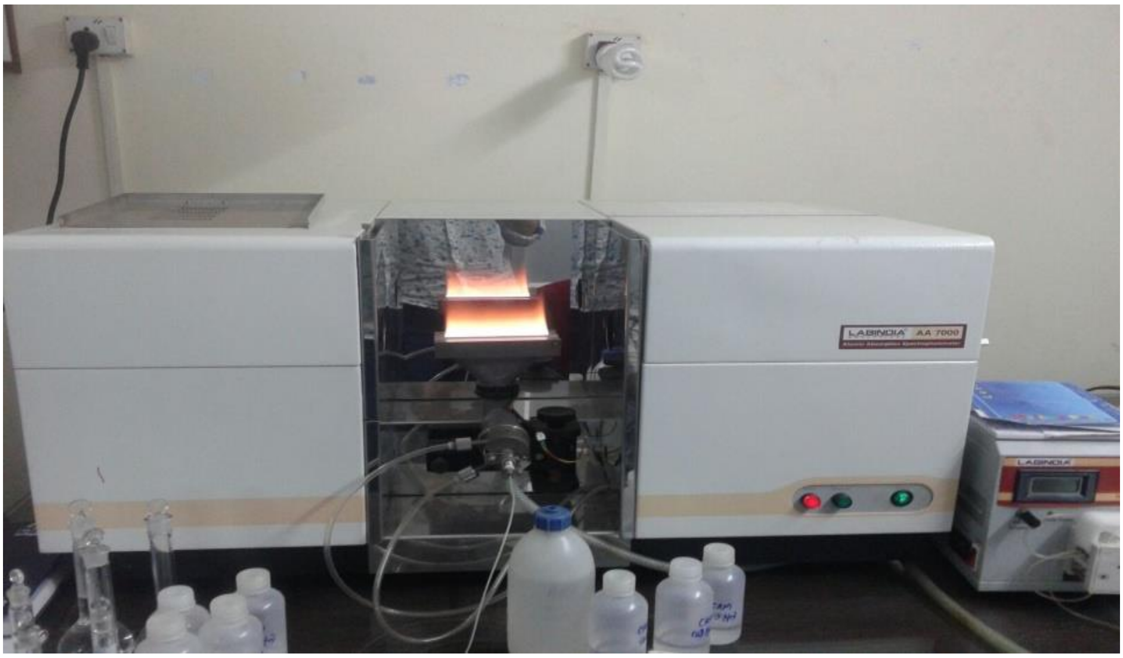

Figure 3.3.10 Atomic absorption spectrometer

11) Bacteriological testing (APHA 22nd Edn.9221 C+B):

The most probable number (MPN) of bacteria present can then be estimated from the number of tubes incubated and the number of positive tubes obtained in the confirmatory test, using specially devised statistical tables. This technique is known as the MPN method.

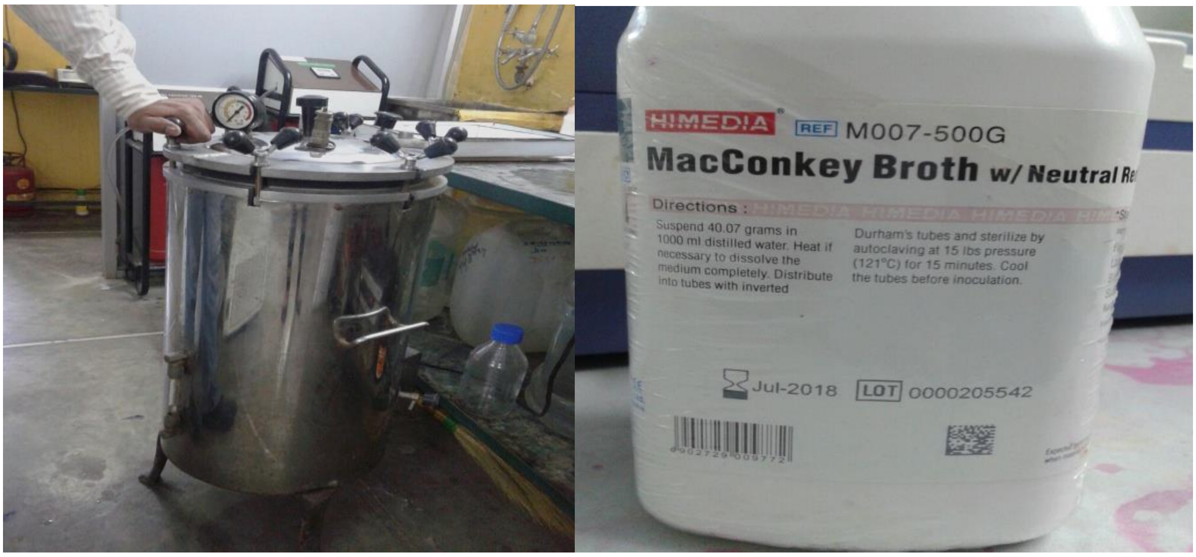

Figure 3.3.11 Autoclave and media used for bacteriological examination

3.3.2 System Analysis using Wasteaware benchmark indicators for sustainable waste management:

(1) System Analysis using Wasteaware benchmark indicators

A safe and environmental friendly method of solid waste management is a global problem. Further, it suffers from two major issues including lack of suitable data and lack of persistent data which can be utilized for comparing the efficiencies of solid waste management system for different cities. In this context, '*wasteaware*' benchmark indicators were introduced which consists of both qualitative and quantitative indicators (Wilson et al, 2013; Wilson et al, 2015). Quantitative indicators comprises of Public Health-collection, Environmental controlled disposal and Resource Management – reuse, reduce and recycling (as percentages) whereas the qualitative indicators are part of governance covering user and provider inclusivity; financial sustainability; and the national policy framework and local institutions (Wilson et al, 2013; Wilson et al, 2015).

Table 3.3.1 The four quantitative indicators for the physical components of a solid waste management system.

No.	Physical Component	Indicator name and definition	Traffic light colour coding				
			LOW	LOW/MEDIUM	MEDIUM	MEDIUM/HIGH	HIGH
1	Public health - waste collection	**Waste Collection Coverage**: % households who have access to a reliable waste collection service	0-49%	50-69%	70-89%	90-98%	99-100%
1.2		**solid waste management and recycling system:** % of waste generated that is collected and delivered to an official facility	0-49%	50-69%	70-89%	90-98%	99-100%
3	Environmental control - disposal	**Controlled treatment or disposal**: % of the total municipal solid waste destined for treatment or disposal which goes to either a state-of-the-art, engineered or 'controlled' treatment / disposal site	0-49%	50-74%	75-84%	85-94%	95-100%
	Resource value - '3Rs' - Reduce, reuse, Recycle	**Recycling rate**: % of total municipal solid waste generated that is recycled. Includes materials recycling and organics valorisation (composting, animal feed, anaerobic digestion).	0-9%	10-24%	25-44%	45-64%	65% and over

Table 3.3.2 Criteria used to derive indicator 3R: Quality of 3Rs – reduce, reuse, recycle – provision.

NO	Criterion	Description
3R.1	Source separation of 'dry recyclables'	Assessed on the basis of the proportion of the total quantity of materials collected for recycling that are collected as clean, source separated materials The focus here is on the relative % of clean, source-separated materials that are recycled, as opposed to materials that are sorted out from 'mixed' wastes – where there will inevitably be much higher levels of contamination. Detailed guidance is provided in the User Manual
3R.2	Quality of recycled organic materials	A qualitative assessment of the likely quality of the recycled product (i.e. animal feed, compost, and the organic product (digestate) from anaerobic digestion) – assessment guidance based on both separation at source and quality control
3R.3	Focus on the top levels of the waste hierarchy	An assessment of the degree of both policy and practical focus on promoting reduction and reuse in 'higher waste generating cities'; and on the '3Rs' – reduction, reuse, recycling – in 'lower waste generating cities'
3R.4	Integration of community and/or informal recycling sector with the formal SWM system	An assessment of how far and how successfully efforts have been made to include the informal recycling sector (in low and middle-income countries) and the community reuse and recycling sector (in higher income countries) into the formal solid waste management system
3R.5	Environmental protection in recycling	Environmental impacts of the recycling chain, from collection through to the separation and processing of the separated materials. NOTE: the environmental impact of waste treatment facilities that also produce materials for recycling (e.g. composting, MBT plants) is considered elsewhere under Indicator 2E
3R.6	Occupational health and safety	Use of appropriate personal protection equipment and supporting procedures

(2) Quantification of indicators using Matrix Method of Evaluation

A simple quantification method has been proposed using the matrix methodology and has been computed for a better understanding of the system analysis methodology carried out and explained in the earlier section. Since the proposed grading system used in the wasteaware benchmarks is low (L), Low/Medium (L/M), Medium (M), Medium /High (M/H) and High (H), a certain weightage has been assigned to each of these. The assigned weights are (L=1, L/M=2, M=3, M/H=4, H=5). The parameters excluded for the study are the background information of the cities and the composition of the waste fraction; since they are not utilized in the grading process.

Table 3.3.3 WHO Standard for drinking water

S. No	Parameters	Acceptable Limits(WHO)	Permissible limits (WHO)
01)	Turbidity, NTU	1	5
02)	pH	6.5-8.5	No relaxation
03)	TDS	500	2000
04)	Sulphate (mg/L)	200	400
05)	Nitrate (mg/L)	45	No relaxation
06)	Ammonical nitrogen(N) (mg/L)	-	No relaxation
07)	BOD at 27 ^{0}c 3 day (mg/L)	-	30 (surface water)
08)	COD (mg/L)	-	250(surface water)
09)	Lead (mg/L)	0.01	No relaxation
10)	Zinc (mg/L)	5	15
11)	Chromium (mg/L)	0.05	No relaxation
12)	Nickel (mg/L)	0.02	No relaxation

Chapter 4

Results and discussion

Laboratory tests were performed for determine the effect of solid waste on groundwater quality. For this purpose different parameter was analysed like; pH, total dissolve solid, nitrate, sulphate, heavy metals, BOD, COD, bacteriological test for leachate sample surface water and ground water.

Table 4.1 Results of testing for leachate samples for physicochemical parameters

S.no	Parameters	Results (sep 2015)	Results (feb 2016)
1.	Conductivity (EC) (micro mhos/cm at 25^{o}C)	2960	2880
2.	pH	7.41	7.8
3.	TDS (mg/L)	1968	2000
4.	Sulphate (mg/L)	50	48
5.	Nitrate (mg/L)	27	28
6.	Ammonical nitrogen(N) (mg/L)	nil	5
7.	BOD at 27 ^{0}c 3 day (mg/L)	2300	2410
8.	COD (mg/L)	7150	7200

Table 4.2 Results of testing for Surface & ground water samples physico-chemical parameters

S.no	Parameters	Results (surface water) Sep -2015	Results (surface water) Feb- 2016	Results (Ground water) Sep-2015	Results (Ground water) Feb-2016
1.	Turbidity, NTU	7	8	40	42
2.	EC (micro mhos/cm at 25^{o}C)	598	616	372	385
3.	pH	8.28	8	7.41	8.2
4.	TDS (mg/L)	389	400	242	250
5.	Sulphate (mg/L)	18	20	63	68
6.	Nitrate (mg/L)	0.15	0.2	BDL	BDL
7.	Ammonical nitrogen(N) (mg/L)	nil	nil	Nil	nil
8.	BOD at 27 ^{0}c 3 day (mg/L)	6.2	6.0	Nil	nil
9.	COD (mg/L)	20	22	Nil	nil

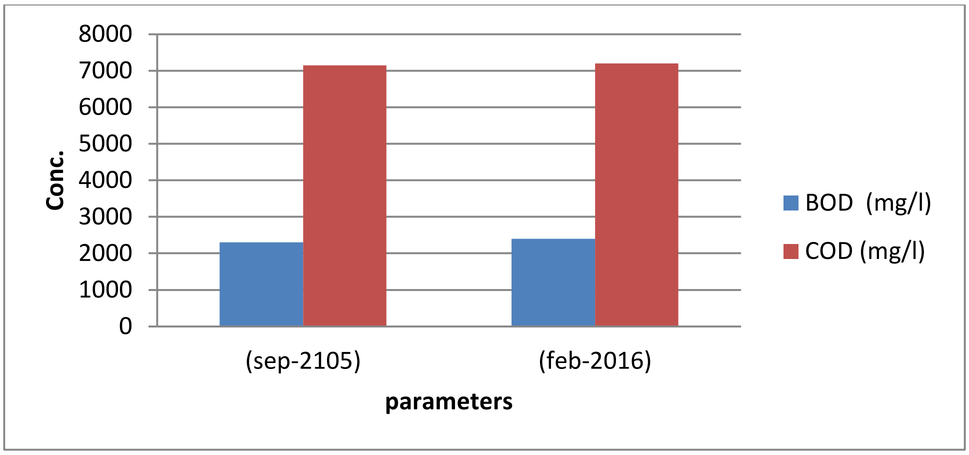

Figure 4.1 Results of BOD and COD for leachate samples

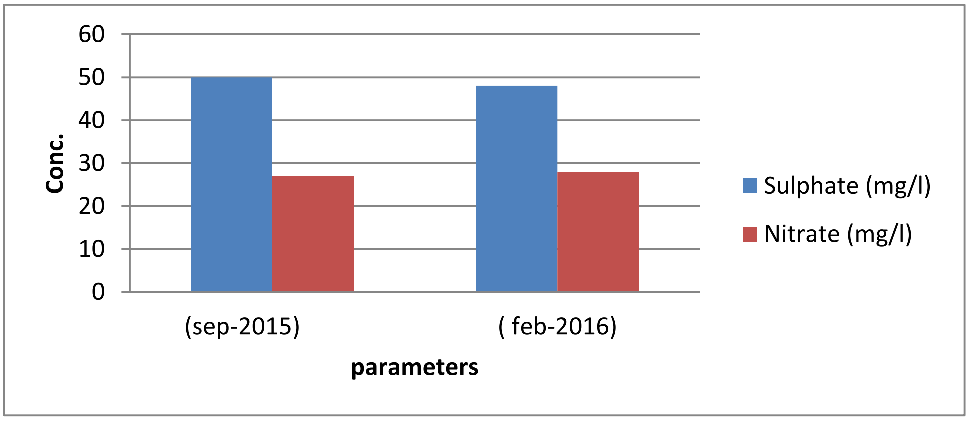

Figure 4.2 Sulphate and Nitrate result for leachate samples

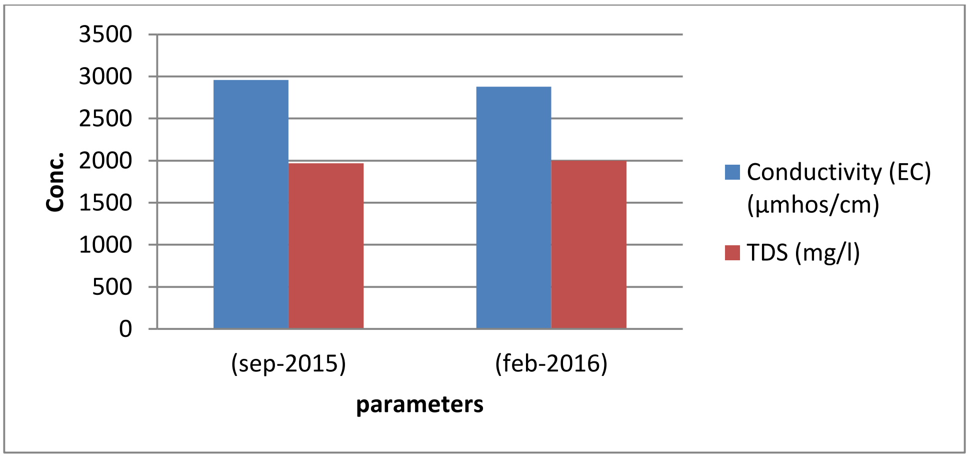

Figure 4.3 Conductivity and TDS result for leachate samples

The pH for leachate sample was found to be between 7.4 and 7.8 for groundwater 7.41and 8.20 and for surface water 8.28 for sample collected in sep 2015 and was 8 and near to 8 for all the sample collected in feb 2016. All leachate samples have high concentration of dissolved solids. The total dissolved solid was found 1968 mg/lt and 2000 mg/l.In groundwater samples dissolved solid was 242 mg/l and in surface water was 389 mg/l. COD indirect measurement of the amount of pollution that cannot be oxidized biologically in a sample of water. Temperature play a significant role in the biodegradation of waste in Solan district temperature is low as compare to most of the cities in India. But in winter season the temperature is very low, it affects the microbiological activities result in lower biodegradation which ultimately increase the COD and BOD. The chemical oxygen demand for leachate sample was 7150 mg/l and 7200 mg/l, which indicate the presence of higher amount of inorganic matter in waste, in ground water the value of COD was nil and in surface it was 20 mg/l and 22 mg/l. and the result also shown that the value of BOD in leachate sample also was very high 2300 mg/l and 2410 mg/l, for groundwater sample it was nil and in surface water it was 6.2 and 6 mg/l

Table 4.3 Results of testing for leachate samples for heavy metals

S.no	**Parameters (heavy metal)**	**Results (sep- 2015)**	**Results (feb-2016)**
1.	Lead (mg/L)	0.0351	0.04
2.	Zinc (mg/L)	0.0838	0.078
3.	Chromium (mg/L)	BDL	BDL
4.	Nickel (mg/L)	0.0168	0.0189
5.	Iron (mg/L)	0.21	0.28

Table 4.4 Results of testing for Surface & ground water samples for heavy metals

S.no	**Parameters**	**Results (surface water) Sep 2015**	**Results (ground water) Sep 2015**	**Results (surface water) (feb 2016)**	**Results (ground water) (feb 2016)**
1.	Lead (mg/L)	0.0241	0.0271	0.0271	0.025
2.	Zinc (mg/L)	0.0137	0.0178	0.014	0.02
3.	Chromium (mg/L)	BDL	BDL	BDL	BDL
4.	Nickel (mg/L)	0.0056	0.0024	0.008	0.0028

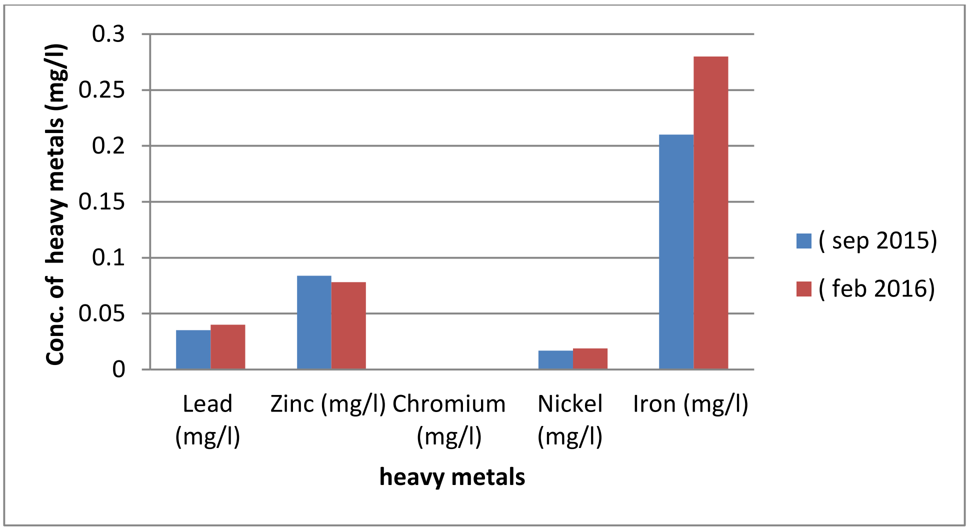

Figure 4.4 Result of heavy metals for leachate sample

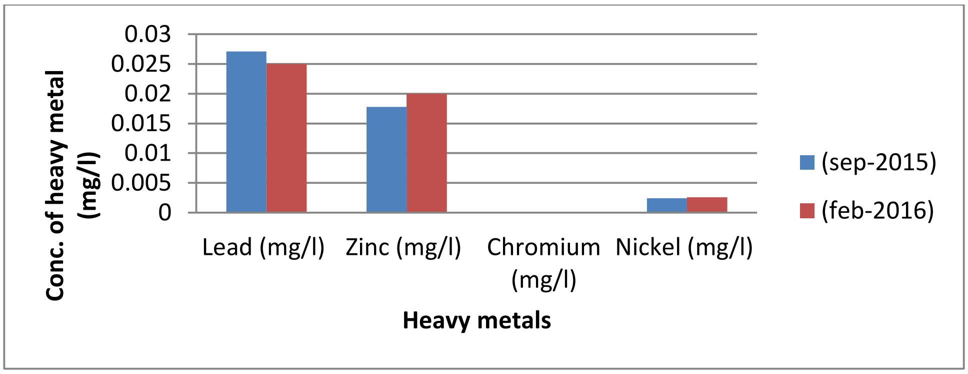

Figure 4.5 Result of heavy metals for surface water sample

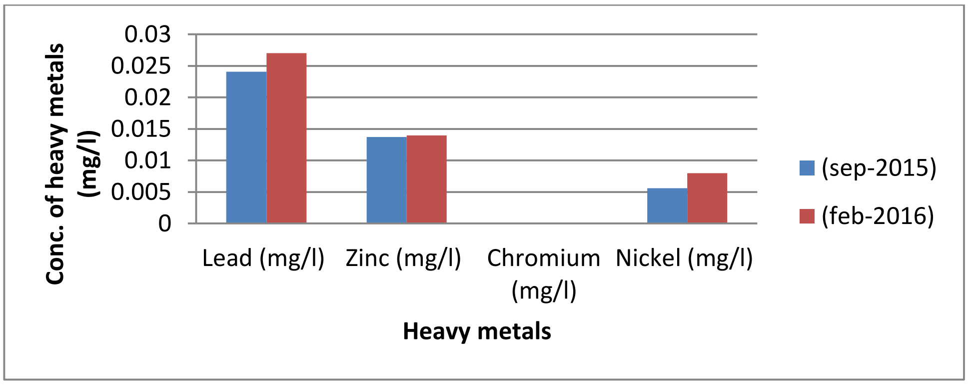

Figure 4.6 Result of heavy metals for ground water sample

In case of heavy metal the amount of the of lead was higher than permissible limits for all sample in leachate sample it was 0.0351 mg/l, for surface water it was 0.0241 mg/l for ground water it was 0.0271 mg/l. Lead is known to cause serious conditions such as anaemia, brain damage and kidney failure. And, because of size and charge similarities, lead can substitute for calcium and included in bones; children are especially susceptible to this effect

Low-Level exposure to chromium can irritate the skin and cause ulceration. Long-term exposure can cause kidney and liver damage, and damage to circulatory and nerve tissue. Chromium often accumulates in aquatic life. The concentration of chromium in leachate, surface and groundwater was found below the detection limit The WHO recommended limit for Cr in drinking water is 0.05ppm/lt. For all samples the concentration of Ni was under the permissible limits for leachate samples it was 0.0168 mg/l, for surface water it was 0.0056 mg/l and for groundwater 0.0024 mg/l.

Concentration of sulphate was 50mg/l and 48 mg/l for leachate sample and 18 mg/l for surface water 63 mg/l for groundwater. All result reveal that the concentration of sulphate in groundwater was higher as compare to leachate and surface water may be because of same natural sources. In the case of nitrate the amount of nitrate in leachate sample was 27 mg/ l and 28 mg/l and in surface water it was 0.15mg/l ad for groundwater it was BDL. Ammonical nitrogen (N) was nil for all samples. Zinc is a trace element that is essential for human health. When people absorb too little zinc they can experience a loss of appetite, decreased sense of taste and smell, slow wound healing and skin sores. Although humans can handle proportionally large concentrations of zinc, too much zinc can still cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anaemia. Very high levels of zinc can damage the pancreas and disturb the protein metabolism, and cause arteriosclerosis. The concentration of Zinc in leachate was to be found 0.0838 mg/l 0.078 mg/l and in surface water the concentration was found 0.0137 for groundwater it was 0.0178 mg/l and 0.02 mg/l. The concentration of Zn was within the WHO permissible limit for all samples.

Table 4.5 Results of testing of biological examination for leachate samples

S.no	**Parameters**	**Results**
1	E. coli	Present
2	Fecal Coliforms	Present

Table 4.6 Results of testing for groundwater and surface water samples

S.no	**Parameters**	**Results**
1	E. coli	Absent
2	Fecal Coliform	Absent

Result of biological examination shows that the number of E.coli and fecal coliforms was present in leachate sample and absent in both water samples.

Table 4.7 Results of testing for physico-chemical parameters for soil samples

S.no	Parameters	Results (sept.)	Results(feb.)
1	pH	7.9	7.11
2	Conductivity (micro mhos/cm at25ºC)	600	560
3	Sulphate (mg/kg)	345	325
4	Nitrate (mg/kg)	17	15
5	Ammonical nitrogen (mg/kg)	18	16

All the result for soil testing reveal that there is no much more adverse effect of dump site on the quality of soil. The pH of the soil sample was found 7.11 conductivity was 560 micro mhos/cm at 25ºC) and in the case sulphate, nitrate, ammonical nitrogen the values was 325 mg/kg, 15mg/kg 16 mg/kg respectively.

Table 4.8 Results of testing for heavy metal parameters for soil samples

S.no	Parameters	Results(mg/kg) Sept-2015	Results (mg/kg) Feb-2016
1	Iron	1.2	1.4
2	Nickel	0.428	0.440
3	Lead	2.908	3.0
4	Chromium	0.050	0.070
5	zinc	1.850	1.860

The results for heavy metals shows that metals may be migrated for the waste as the values of metals, iron, nickel, chromium and zinc was found 1.2 mg/kg, 0.426 mg/kg ,0.050 mg/kg and 1.850 mg/kg. The value for lead was little bit higher side it was 2.908 mg/kg. pH is a key factor which affect the leaching of the metals from upper soil profile to lower. If the pH is low it will accelerate the migration of metal from upper to lower soil profile. In municipal solid waste dump site the pH is directly depends on anaerobic decomposition of waste. More anaerobic decomposition more acid will produce, it will decrease the pH and in acidic condition metal will moves from upper to lower soil profile.

Benchmark indicators for integrated sustainable waste management in city:

Here we presents a set for indicator for integrated sustainable waste management (ISWM) in city, it allows the benchmarking of a city's performance and monitoring developments over time. This system allow us to comparison of different cities. The indicator set includes essential quantitative indicators as well as qualitative composite indicators.

Table 4.9 Comparison of Wasteaware parameters for Solan compared with other tier –II cities of India and Asia.

No.	Category	Indicator	Solan City Results	Surat City Results	Lahore City Results
Background Information of the City					
B1	Country Income Level	World Bank Indicator Level	Lower-Middle	Lower-Middle	Lower-Middle
		GNI per Capita	$1,420	$1,420	$1,140
B2	Population of the City	Total Population of the City	39,256	4,600,000	8,160,000
B3	Waste Generation	MSW Generation (tons/year)	8,395	45,6250	1,916,000
W1	Waste per Capita	MSW per capita (kg per year)	109.5	119	219
W2	Waste Composition	3 key fractions – as % wt. of total waste generated			
W2.1	Organic	Organics (food and green wastes)	56%	54%	65%
W2.2	Paper	Paper	18.2%	8%	2%
W2.3	Plastics	Plastics	14.50%	10%	12%
1.1	Public health – Waste collection	Waste collection coverage	90% (M/H)	95%(M/H)	77%(M)
1C		Quality of waste collection service	80% (M/H)	95%(M/H)	58% (M)
2	Environmental control – waste treatment and disposal	Controlled treatment and disposal	30% (L)	55%(L/M)	8%(L)
2E		Degree of environmental protection in waste treatment and disposal	0%(L)	37% (L/M)	37% (L/M)
3	3Rs – reduce, reuse and recycling	Recycling rate	0% (L)	30% (L)	35% (M)
3R		Quality of 3Rs provision	17%(L)	29% (L/M)	17%(L)
Governance Factors					
4U	User inclusivity	User inclusivity	M (75%)	M (80%)	L/M (37%)

4P	Provider inclusivity	Degree of provider inclusivity	M (78%)	M (82%)	L/M (50%)
6N	Sound institutions, proactive policies	Adequacy of national SWM framework	L/M (60%)	L/M (60%)	L/M (29%)
6L		Degree of institutional coherence	M (75%)	M (77%)	M/H (62%)

It is observed from Table 4.9 that all of these cities experience similar nature of solid wastes generated with the highest proportion of organic waste. It is observed that for Lahore city which has almost 14 times the population of Solan almost generates twice the amount of waste per capita due to higher population density. Further, comparison of the '*wasteaware*' benchmarks parameters for Solan, Mohali, Panchkula, Surat and Lahore shows that Solan, Mohali and Surat have very good collection efficiencies as compared to Panchkula and Lahore which showed 'low-medium' and 'medium' index on wasteaware benchmark indicators respectively. The major difference between Mohali, Panchkula, Solan, Surat and Lahore is in the disposal methods and in the efficiency of *3R method*. While Surat scores a 'Low/Medium' index for environmental controlled waste treatment and disposal method as reported earlier (Wilson et al, 2013), Mohali and Panchkula scores 'Low' index similar to studies carried out in other tier – II cities of India including Solan and Lahore (Wilson et al, 2015) scores in the same category. This is because the disposal sites are unsanitary landfill in nature. Though, EM and bacterial solution and levelling of waste are done, these are not proper engineering solutions to handle the hazards arising from solid waste. Further, there is no lining provided at the landfill site to prevent the percolation of leachate in groundwater thereby contributing to environmental hazard Further, Surat and Lahore scores a 'Low/Medium' index for efficiency of *3R* methodology (reduce, reuse and recycle) as reported in earlier studies (Wilson et al, 2013; Wilson et al, 2015), however Solan, Mohali, Panchkula scores 'Low' index in the same category as no recycling facilities exists in these cities. (Rana.R., et al 2016)

The weights assigned for the respective indicators (in brackets) have been presented. The final scores obtained using the matrix methodology has been summarized in Table 4.10

Table 4.10 Weightage Assignment for evaluation using matrix method

No.	Category	Indicator	Solan City Results	Surat City Results	Lahore City Results
Quantitative Indicators (Public Health, Environmental Control, 3R)					
1.1	Public health – Waste collection	Waste collection coverage	76%(M) (3)	95%(M/H) (4)	77%(M) (3)
1C		Quality of waste collection service	65%(L/M) (2)	95%(M/H) (4)	58% (M) (2)
2	Environmental control – waste treatment and disposal	Controlled treatment and disposal	30%(L) (1)	55%(L/M) (2)	8%(L) (1)
2E		Degree of environmental protection in waste treatment and disposal	L (0%) (1)	L/M (37%) (2)	L/M (37%) (2)
3	3Rs – reduce, reuse and recycling	Recycling rate	0% (L) (1)	30% (M) (3)	35% (M) (3)
3R		Quality of 3Rs provision	L (9%) (1)	M (29%) (3)	L/M (17%) (2)
Qualitative Indicators (Governance Factors)					
4U	User inclusivity	User inclusivity	M (71%) (3)	M (80%) (3)	L/M (37%) (2)
4P	Provider inclusivity	Degree of provider inclusivity	M (75%) (3)	M (82%) (3)	L/M (50%) (2)
6N	Sound institutions, proactive policies	Adequacy of national SWM framework	L/M (60%) (2)	L/M (60%) (2)	L/M (29%) (1)
6L		Degree of institutional coherence	M (72%) (3)	M (77%) (3)	M/H (62%) (4)

Table 4.11 Summary of scores obtained using matrix method

No.	Category	Indicator	Solan City Results	Surat City Results	Lahore City Results
Quantitative Indicators (Public Health, Environmental Control, 3R)					
1.1	Public health – Waste collection	Waste collection coverage	3	4	3
1C		Quality of waste collection service	2	4	2
2	Environmental control – waste treatment and disposal	Controlled treatment and disposal	1	2	1
2E		Degree of environmental protection in waste treatment and disposal	1	2	2
3	3Rs – reduce, reuse and recycling	Recycling rate	1	1	2
3R		Quality of 3Rs provision	1	3	3
Total Score (Quantitative Indicators)			09	16	13
Maximum Score			30	30	30
Weightage (%)			**30**	**53**	**43**
Qualitative Indicators (Governance Factors)					
4U	User inclusivity	User inclusivity	3	3	2
4P	Provider inclusivity	Degree of provider inclusivity	3	3	2
6N	Sound institutions, proactive policies	Adequacy of national SWM framework	2	2	1
6L		Degree of institutional coherence	3	3	4
Total Score (Quantitative Indicators)			11	11	9
Maximum Score			20	20	20
Weightage (%)			**55**	**55**	**45**
Total Score (Overall)			9+11=20	16+11=27	13+09=22
Total Maximum Score			30+20 =50	30+20 =50	30+20 =50
Overall Weightage (%)			**40**	**54**	**44**

The final scores obtained using the matrix methodology has been summarized in Table 4.11 The matrix method for evaluation showed the best possible results for Surat city with an overall score of 54%, being classified as L/M category. Qualitative and Quantitative parameters for Surat were almost of equal score (Quantitative parameters = 50%, Qualitative parameters = 55%). In contrast, the quantitative parameters were significantly less than the qualitative parameters for Solan. So it is clear that Governance factor is more effective than CR factor. Interestingly, governance factors for all the Indian cities were equal with 55% of weightage. The main difference between categorization of scores between Surat and Solan is primarily due to increased scores for Surat city for better environmental control facilities (2 and 2E) and recycling facilities (3, 3R).

Chapter 5
Conclusion

In this study, leachate, surface, groundwater and soil samples were collected from waste dump site to find out the effect solid waste on the groundwater quality. Samples were collected from hand pumps, surface water body and leachate sample from waste dump site in sampling bottles and different physic-chemical parameters were analysed. The concentrations of metals were determined with the instruments like; AAS. The results of this study revealed that metal concentration, BOD, COD was high in all of the leachate samples. Zn concentration was within the limits all sample as recommended by WHO but the concentration was higher. Lead is also leaching out from waste as lead concentration was high in surface and groundwater and in some sample the value of lead concentration was exceeded from the WHO recommended value. Chromium was also found in all samples collected from groundwater& surface water in some samples the concentration of chromium was higher. E.coli and fecal coliform was also found in all leachate samples but absent in groundwater & surface water show the presence of fecal matter in waste. All the result for soil testing reveal that there is no much more adverse effect of dump site on the quality of soil. The results for heavy metals shows that metals may be migrated for the waste to soil.

From the results, it can be concluded that the metals present in solid waste can migrate into groundwater and pollute it and contribute to degradation of land, water and air.

Analysis of integrated sustainable waste management shows that the recycling and reuse system of the waste in the city is very poor and treatment process is also very low or we can say that overall solid waste management system is not adequate. So, there is a need to change in land use pattern and to adapt new methods for waste utilization**.** The countries like U.S, Germany, UK, Denmark and Netherlands have many alternatives for disposal and recycle and reuse of municipal solid waste. Use of organic waste as manure in agriculture provides a feasible alternative for its safe disposal and improves soil environment and crops production. However, a judicious amendment strategy has to be developed to abate the land and water pollution from the pollutants presents in it.

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