QUALITY ASSESSMENT OF DISCHARGED WATER FROM MOTOR SERVICING CENTER: A CASE STUDY OF DOON VALLEY

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April, 2010

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A thesis submitted in partial fulfillment of the requirements for the Degree of
Master of Technology
(Health Safety and Environmental Engineering)

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2008-10

Under the guidance of
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CERTIFICATE

This is to certify that the work contained in this thesis titled ***"Quality Assessment Of Discharged Water From Motor Servicing Center: A Case Study Of Doon Valley"*** has been carried out by **H. Tonsana** under my supervision and has not been submitted elsewhere for a degree.

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TO WHOM IT MAY CONCERN

This is to certify that **Mr. H. TONSANA (R070208004)**, student of M. Tech Health, Safety and Environmental Engineering from University of Petroleum and Energy Studies, Dehradun has worked on a research project titled **"Product penetration and consumption pattern of Automotive Lubricants – Environment concerns in Uttarakhand"** sponsored by Uttarakhand State Council of Science and Technology (UCOST), Dehradun, Uttarakhand.
Wish him all the best in his future.

Yours Sincerely,

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Acknowledgement

I sincerely thank the University for providing me with the facilities to complete my studies.

I sincerely thank my guide **Mrs. Kanchan Deoli Bahukhandi**, M.Tech HSE Course Coordinator, for providing me an opportunity to work under her guidance and extending her unflinching support, giving me suggestions and directions that have helped me in the successful completion of my project work. I thank her for providing me an opportunity to work under the project **"Product penetration and consumption pattern of Automotive Lubricants – Environment concerns in Uttarakhand"** sponsored by Uttarakhand State Council of Science and Technology (UCOST).

I would like to thank **Dr. Pradeep Joshi,** Associate Head Petroleum and Earth Science, UPES and Project-in-charge of the said project and **Ms. Mohini Singh** for their support and help which has resulted in the successful completion of this work.

I thank my parents and friends who are my well wishers for their help and blessings without which this project wouldn't have been a success.

My heartfelt thanks to each and every one connected with this work directly or indirectly.

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ABBREVIATIONS

APHA - American Public Health Association

BIS – Bureau of Indian Standards

Ca – Calcium

Cl – Chloride

COD – Chemical Oxygen Demand

DO – Dissolved Oxygen

EDTA - Ethylene-diamine tetra acetic acid

K – Potassium

Mg - Magnesium

pH – Hydrogen Ion Concentration

TDS – Total Dissolved Solids

Temp – Temperature

TSS – Total Suspended Solids

WHO – World Health Organisation

Abstract

The project entitled **"Quality Assessment of Discharged Water from Motor Servicing Center: A Case Study of Doon Valley"** is a part of the main project *"Product Penetration and Consumption Pattern of Automotive Lubricants - Environment Concerns in Uttarakhand"* of Uttarakhand Council of Science and Technology (UCOST), Govt. of Uttarakhand, Dehradun. This project has given main emphasis on the assessment of the discharged water from the Motor Servicing Centers of Doon Valley which are either discharged in the Municipal Sewage System or the nearest natural water bodies available. Most ecological problems are the net result of such environmental and social impacts of human activity in the specific area. This project has underlined the identification, assessment and management of cumulative trends in environmental parameters on the regional basis, which ultimately impact pollution trend of the country and the world as well.

The result of the assessment shows that the physical and chemical parameters of the discharged water are deviated from the standard values of water quality prescribed by WHO, BIS.

Disposal of discharged water from the Servicing Centre should be prohibited in the city limit to avoid any leaching process in to the groundwater or to provide sewerage system or treatment plant if it is within the city limit. It is suggested that some low cost and easy to implement techniques may be provided to the Motor Servicing Centre to avoid groundwater contamination.

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CHAPTER – 1

INTRODUCTION

1.1 Background

As per the latest estimate of Central Pollution Control Board, about 29,000 million litre/day of wastewater generated from class-I cities and class-II towns out of which about 45% (about 13000 mld) is generated from 35 metro-cities alone. The collection system exists for only about 30% of the wastewater through sewer line and treatment capacity exists for about 7000 million litre/day. Thus there is a large gap between generation, collection and treatment of wastewater. A large part of un-collected, un-treated wastewater finds it way to either nearby surface water body or accumulated in the city itself forming cesspools. In almost all urban centres cesspools exist. These cesspools are good breeding ground for mosquitoes and also source of groundwater pollution. The wastewater accumulated in these cesspools gets percolated in the ground and pollute the groundwater. Also in many cities/towns conventional septic tanks and other low cost sanitation facilities exists. Due to non-existence of proper maintenance these septic tank become major source of groundwater pollution. In many urban areas groundwater is only source of drinking. Thus, a large population is at risk of exposed to water borne diseases of infectious (bacterial, viral or animal infections) or chemical nature (due to fluoride or arsenic). Water born diseases are still a great concern in India.

Pollutants are being added to the groundwater system through human activities and natural processes. Solid waste from industrial units is being dumped near the factories, and is subjected to reaction with percolating rainwater and reaches the groundwater level. The percolating water picks up a large amount of dissolved constituents and reaches the aquifer system and contaminates the groundwater. The problem of groundwater pollution in several parts of the country has become so acute that unless urgent steps for abatement are taken, groundwater resources may be damaged.

The quality of groundwater depends on a large number of individual hydrological, physical, chemical and biological factors. Generally higher proportions of dissolved constituents are found in groundwater than in surface water because of greater interaction of ground water with various materials in geologic strata. The water used for drinking purpose should be free from any toxic elements, living and nonliving organism and excessive amount of minerals that may be hazardous to health. Some of the heavy metals are extremely essential to humans, for example, Cobalt, Copper, etc., but large quantities of them may cause physiological disorders. The contamination of groundwater by heavy metals has assumed great significance during recent years due to their toxicity and accumulative behavior. These elements, contrary to most pollutants, are not biodegradable and undergo a global eco-biological cycle in which natural waters are the main pathways. The determination of the concentration levels of heavy metals in these waters, as well as the elucidation of the chemical forms in which they appear is a prime target in environmental research today.

A vast majority of groundwater quality problems are caused by contamination, over-exploitation, or combination of the two. Most groundwater quality problems are difficult to detect & hard to resolve. The solutions are usually very expensive, time consuming & not always effective. An alarming picture is beginning to emerge in many parts of our country. Groundwater quality is slowly but surely declining everywhere. Groundwater pollution is intrinsically difficult to detect, since problem may well be concealed below the surface & monitoring is costly, time consuming & somewhat hit-or-miss by nature. Many times the contamination is not detected until obnoxious substances actually appear in water used, by which time the pollution has often dispersed over a large area. Essentially all activities carried out on land have the potential to contaminate the groundwater, whether associated with urban, industrial or agricultural activities. Large scale, concentrated sources of pollution such as industrial discharges, landfills & subsurface injection of chemicals & hazardous wastes, are an obvious source of groundwater pollution. These concentrated sources can be easily detected & regulated but the more difficult problem is associated with diffuse sources of pollution like leaching of agrochemicals & animal wastes subsurface discharges from latrines & septic tanks & infiltration of polluted urban run-off & sewage where sewerage does not exists or defunct. Diffuse sources can affect entire aquifers, which is difficult to control & treat. The only solution to diffuse sources of pollution is to integrate land use with water management. Once pollution has entered the sub-surface environment, it may remain concealed for many years, becoming dispersed over wide areas & rendering groundwater supplies unsuitable for human uses.

1.2 Water Quality

Water quality is the physical, chemical and biological characteristics of water. The most common standards used to assess water quality relates to drinking water, safety of human contact and for the health of ecosystems. The parameters for water quality are determined by the intended use. Work in the area of water quality tends to be focused on water that is treated for human consumption or in the environment.

Environmental water quality, also called **ambient water quality,** relates to water bodies such as lakes, rivers, and oceans. Water quality standards vary significantly due to different environmental conditions, ecosystems, and intended human uses.

Some people use water purification technology to remove contaminants from the municipal water supply they get in their homes, or from local pumps or bodies of water. For people who get water from a local stream, lake, or aquifer (well), their drinking water is not filtered by the local government.

1.3 Common Groundwater Contaminants

1) **Nitrates:** Dissolved nitrate is most common contaminant in groundwater. High level can cause blue baby disease (Methamoglobinamia) in children, may form carcinogens & can accelerate eutrophication in surface waters. Sources of nitrates include sewage, fertilizers, air pollution, landfills & industries;

2) **Pathogens**: bacteria & viruses that cause water borne diseases such as typhoid, cholera, dysentery, polio, and hepatitis. Sources include sewage, landfills, septic tanks & livestock's;

3) **Trace metals**: include Lead. Mercury, Cadmium, Copper, Chromium & Nickel. These metals can be toxic & carcinogenic. Sources include industrial & mine

discharges, fly ash from thermal power plants either due to fall out or disposal in ash ponds. Industrial solid waste dumping and leaching into groundwater through rainwater;

4) Inorganic Constituents: Inorganic dissolved salts accumulation such as SO_4, Chloride, etc. along with Na, K, building up high dissolved solids and combination of Carbonates, Bicarbonates along with Ca and Mg building up high hardness of water and converting soft/sweet water in to hard water creating gastrointestinal problems in human being if they consume groundwater as drinking source;

5) Organic compounds: include volatile & semi-volatile organic compounds like petroleum derivatives, PCBs pesticides. Sources includes agricultural activities, street drainages, sewage landfills, industrial discharges, spills, vehicular emissions fall out etc.

Figure 1 : Distribution of Common Ground water contaminants

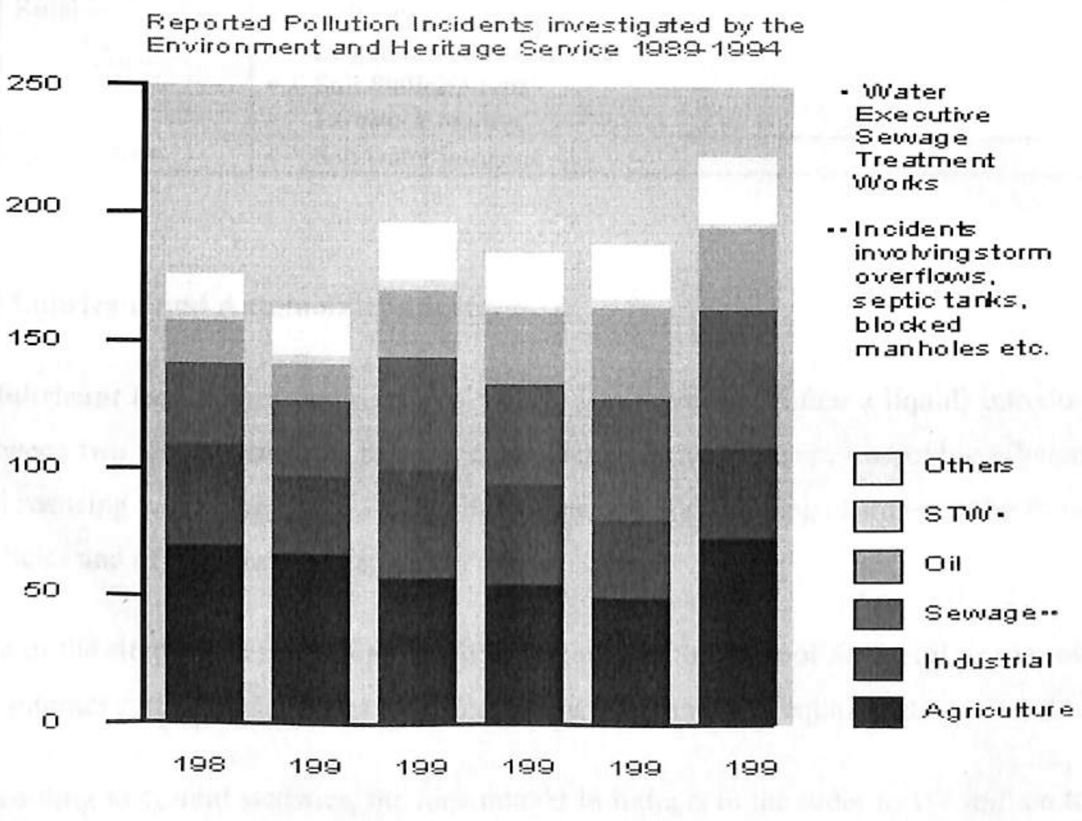


Table 1: Land-use activities & their potential threat to groundwater quality

Land Use	Activities potential to groundwater pollution
Residential	• Un-sewered sanitation • Land & stream discharge of sewage • Sewage oxidation ponds • Sewer leakage, solid waste disposal, landfill leachate • Road & urban run-off, aerial fall out
Industrial & Commercial	• Process water, effluent lagoon etc. • Land & stream discharge of effluents • Tank & pipeline leakage & accidental spills. • Well disposal of effluent • Aerial fall out • Landfill disposal & solid wastes & Hazardous wastes • Poor housekeeping • Spillage & leakages during handling of material
Mining	• Mine drainage discharge • Process water, sludge lagoons • Solid mine tailings • Oilfield spillage at group gathering stations
Rural	• Cultivation with agrochemicals • Irrigation with wastewater • Soil Stalinizations • Livestock rearing
Coastal areas	• Salt water intrusion

1.4 Lubricant and Automobile Industry

A **lubricant** (sometimes referred to as "lube") is a substance (often a liquid) introduced between two moving surfaces to reduce the friction between them, improving efficiency and reducing wear. They may also have the function of dissolving or transporting foreign particles and of distributing heat.

One of the single largest applications for lubricants, in the form of motor oil, is to protect the internal combustion engines in motor vehicles and powered equipment.

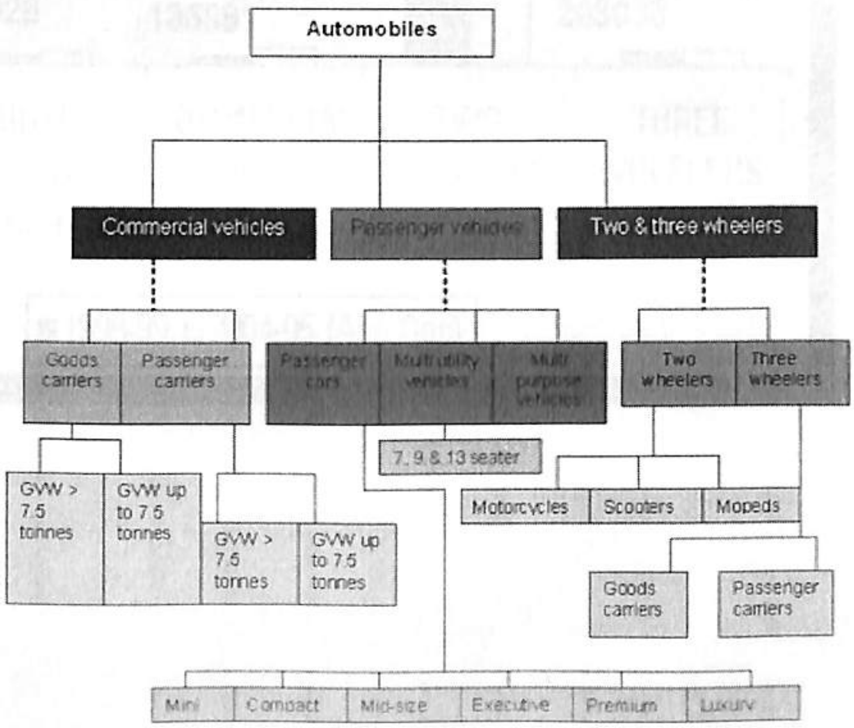
According to current statistics, the lube market in India is in the order to 1 + million tons per annum, with a prevailing annual growth rate of 3.5%. Since lube oil is the highest-value component of a barrel of crude oil and most of the lube oil gets used only once, it becomes one of the world's largest bulk pollutants for

- Water
- Air &
- Soil

Thereby highly contributing to the low quality of life. Therefore, there is an urgent need to systematically carry out a study to conserve it and use it scientifically, so that emissions are within the prescribed limits & no suspended particulate matters are ejected in the atmosphere which poses serious environment pollution & wastage of high value lubricants.

1.5 Automobile Industry in India

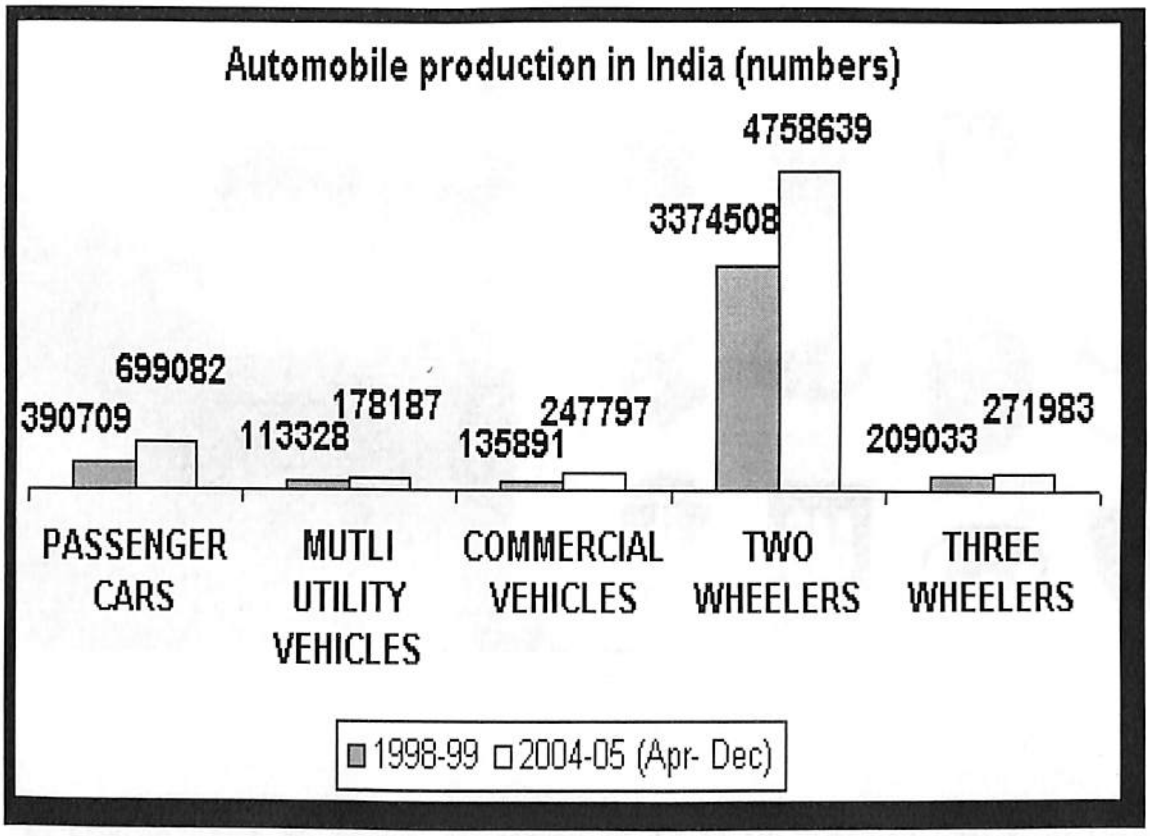
The automobile industry in India is the **ninth** largest in the world with an annual production of over 2.3 million units in 2008. In 2009, India emerged as Asia's fourth largest exporter of automobiles, behind Japan, South Korea and Thailand



Following economic liberalization in India in 1991, the Indian automotive industry has demonstrated sustained growth as a result of increased competitiveness and relaxed restrictions. Several Indian automobile manufacturers such as Tata Motors, Maruti Suzuki and Mahindra and

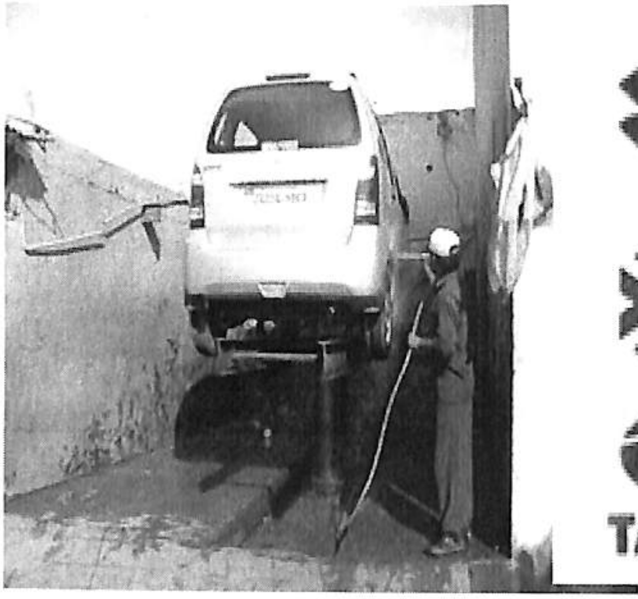
Mahindra, expanded their domestic and international operations. India's robust economic growth led to the further expansion of its domestic automobile market which attracted significant India-specific investment by multinational automobile manufacturers. In February 2009, monthly sales of passenger cars in India exceeded 100,000 units.

Figure 2 : Automobile productions in India



1.6 Motor Servicing Center

A Motor Servicing Centre performs lots of activity which includes all kind of Cleaning, Mechanical, Electrical Work & Denting / Painting. Taking care of Private / Passenger Cars involves heavy utilisation of water resources and the washed away water becomes the source of contaminants in local water bodies. AC servicing and other servicing is also the source of contaminants. Car Wash may be Interior or Exterior Cleaning.



The vehicles which are washed extensively in the Motor Servicing Centers of Doon Valley are:

- Small Car = Maruti 800, Esteem, Indica, Indigo, Ikon, Honda City Etc.
- Big Car = Tavera, Qualis, Innova, Scorpio, Sumo, Bolero Etc.

Every Motor Company has their own Servicing Centre and the effective utilisation of water resources differs from company to company servicing station. The effluent of the washed water is either disposed to local water bodies or goes underground.

1.7 Present Study

The complexity of water quality as a subject is reflected in many types of measurements of water quality indicators. Considering the above mentioned significance and problems an attempt is made to assess the discharged water from the Motor Servicing Station through this study. The physical and chemical parameters of water are analysed in the HSE Laboratory of UPES, Dehradun. No such study in India could not be found till date.

CHAPTER – 2

LITERATURE REVIEW

In the past some studies has been made in relation to the contamination of water quality due to hydrocarbon products but the assessment at Motor Servicing Center was not found. No National Journal or Reports has been found in regards to this study.

Dissolution of petroleum-derived products in water Ihor Lysyj and Edward C. Russell. It was discovered that substantial quantities of organic matter can be introduced into an aqueous solution as a result of contact between the oil film and the water. The significance of results of this study is examined in terms of practical requirements for design of bilge and ballast wastewater treatment equipment.

Historical oil contamination travel distances in ground water at sensitive geological sites in Maine, USA ***George Seel, Division of Technical Services, Bureau of Remediation & Waste Mgmt., MDEP, USA*** **APRIL 30, 2002** Based on findings that new facilities in Maine do have oil discharges despite the use of state-of-the-art technology (including secondary containment) and may subsequently pose a risk to groundwater and nearby receptors.

Petroleum Products in Drinking-water ***Background document for development of WHO Guidelines for Drinking-water Quality*** The above approach provides a sound basis for assessing the potential health risks associated with large-scale contamination of drinking-water by petroleum products.

The lubricant oil discarded in the nature is a cause of concern due to a non-quantified impact, because of its potential chronic damage to the human health. It is impossible to avoid totally the emission of this effluent directly in the environment ***(Wright et al., 1993)***, and the impact caused a decreasing of microbiota biodiversity ***(Atlas et al., 1991)***.

The pollution generated by discarding a ton of used oil per day is equivalent to the domestic sewer of 40000 inhabitants, besides the fact that one liter of this substance is able to deplete the oxygen of a million liters of water. Also, the indiscriminate burning of the used lubricant oil, without previous treatment of desmetalization, generates significant metallic oxides emissions, besides other toxic gases. as the dioxin and sulphur oxides *(Ambientebrasil, 2006).*

In this context, ***Burns et al. (1994)*** had observed that the lubricant oil could persist in the environment for more than six years in some ecosystems, causing chronic problems for the biota. Even under the most controlled laboratorial conditions, the complete metabolism of the oil by microorganisms takes weeks to months ***(Atlas, 1995).*** Thus, the characterization of the environmental behavior and the lubricant properties are bases to the development of new fluids, and the biodegradability is the most important aspect when the substance is discarded in the environment ***(Eisentraeger et al., 2002).***

Amongst the lubricant oils components, the polyaromatic hydrocarbons have been identified as carcinogenics by the **International Agency for Research on Cancer (1983)** and, as the mineral oils present a bigger concentration in its composition, they also become more harmful, compared with the synthetic ones, when displayed to the living beings, including humans ***(Cotton et al., 1977).***

Susan D. Haigh et al., **(September 2007)** studied the **Fate and effects of synthetic lubricants in soil: biodegradation and effect on crops in field studies.** A range of synthetic lubricants applied to field plots was found to degrade more rapidly and extensively than mineral oil-based lubricants, but not as rapidly or extensively as a natural vegetable oil. Loss of the oils was enhanced by the addition of nitrogen and the greatest losses were found in the warmer summer months. The extent and rate of biodegradation of the oils was much lower than that found previously in laboratory-based studies, but the relative biodegradabilities of the oils was consistent with previous results. At application rates of 5 $l \cdot m^{-2}$, both synthetic and mineral-based oils as well as the vegetable oil adversely affected the growth of spring wheat. However, the oils which caused the greatest effects were not necessarily the most persistent. Where sampling occurred over two growing seasons, the effect of residual oil was significantly reduced in the second season after oil application.

Paulo Renato Matos Lopes et al., (2004) studied the **Evaluation of the biodegradation of different types of lubricant oils in liquid medium.** The aim of this work was to study the biodegradation of different types of automotive lubricant oils adapted to the aqueous medium using a base inoculum and an aqueous inoculum. Four treatments were carried out in two consecutive and similar experiments: T1 (control); T2 (half-synthetic oil); T3 (mineral oil); T4 (used oil). The results showed the following decreasing order of CO_2 production in the Bartha and Pramer respirometers: T4 > T2 > T3 > T1. Thus, the used lubricant oil showed with highest biodegradability, followed by the half-synthetic one and the mineral oil. It was also observed that the mineral lubricant presented a longer period of adaptation compared to the half-synthetic one.

Gurdeep Singh and Sambhu Jha, April 2002, The Indian Mining and Engineering Journal. Efficacy Analysis of Treatment Plants for Workshop and Mine Effluents in Mahanadi Coalfield Ltd. Study describes the quality and quantity of influent entering these treatment plants, technical details, comparison w.r.t. the conventional/standard systems, cost of construction, operation and maintenance, manpower etc. Samples were collected from the inlet and outlet of these treatment plants and were analyzed at ISM, laboratory to generate the primary data. Efficacy analysis has also been done on the basis of secondary and primary data and effluent quality has been compared with the prescribed standards.

Santa Clara Valley Nonpoint Source Control Program. 1992. *Source Identification and Control Report.* Woodward Clyde Consultants. 96 pp. The authors made an attempt to calculate metal loadings from leaks of motor oil, gasoline, and coolant leaks from cars, as well as illegal disposal from oil and coolant changes. The data on leak and illegal disposal rates is extremely sketchy. For example leak rates of 0.3, 0.01, and 1.2 % of all cars were cited for gasoline, motor oil and coolant, respectively. The rate of illegal disposal.

Rafael Vazquez-Duhalt (July 2003) studied the **Environmental impact of used motor oil**. The production and fate of used motor oil were analyzed and the effects on soil and aquatic organisms were described. The combustion of waste crankcase oil, with particular reference to environmental impact, is discussed. The mutagenic and carcinogenic effects of used motor oil are also described. Information on the biodegradation of lubricating motor oil is also reviewed.

The available information shows that used motor oil is a very dangerous polluting product. As a consequence of its chemical composition, world-wide dispersion and effects on the environment, used motor oil must be considered a serious environmental problem.

CHAPTER – 3

OBJECTIVE

I. To assess the Quality of Water which are being discharged from the Motor Servicing Centre as it has direct bearing on the quality of life of common man.

II. To generate reference data for future studies.

III. To determine the extent of underground water contamination due to the discharge water from the Motor Servicing Center.

IV. To acknowledge the need of a low cost waste water treatment system for the Motor Servicing Center.

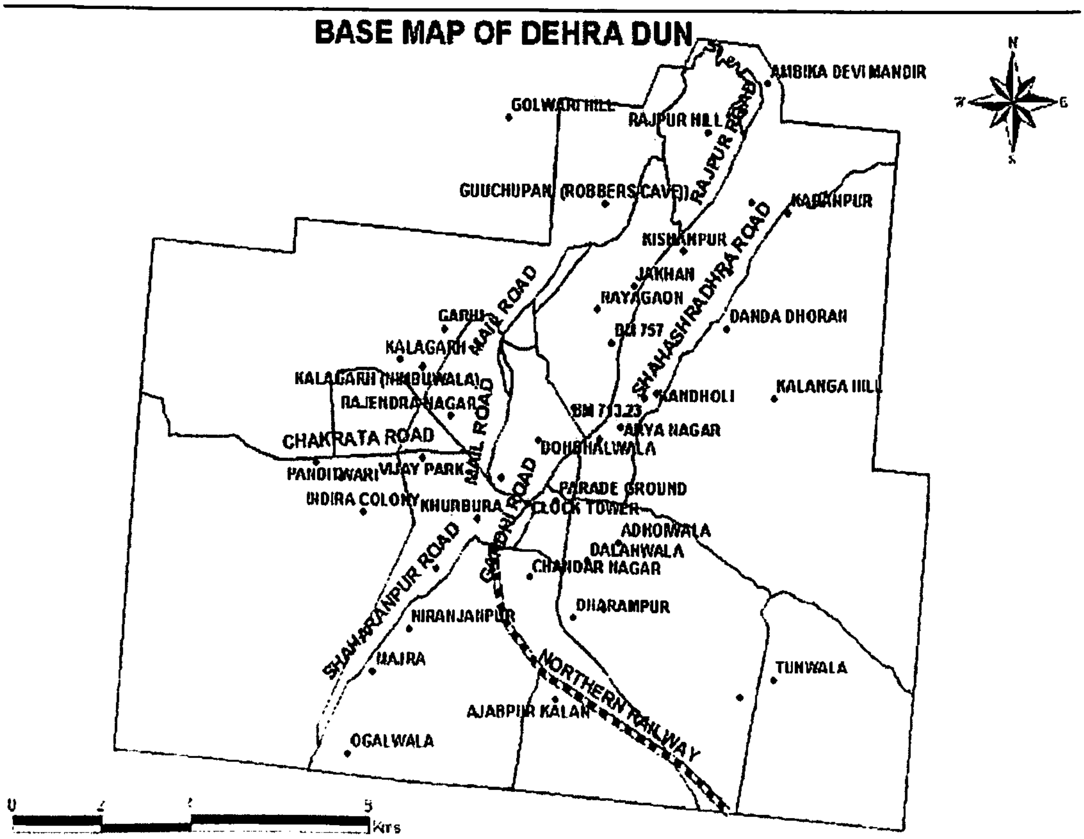
CHAPTER – 4

AREA OF STUDY

4.1 Geography

The geography of Dehradun shows it as being located at the center of the Doon Valley in the state of Uttaranchal, forming part of the Garhwal Himalayas. The Himalayas lie to its north, the Shivalik range to its south, the Ganges to its east and the Yamuna to its west. It is about 235 kilometers from Delhi. Once under British rule, Dehradun has preserved its colonial tinge despite considerable modernization. The magnificent landscapes and excellent infrastructure attract numerous visitors to Dehradun.

Dehradun enjoys a pleasant climate. During the summer months, temperatures range between 36°C and 16.7°C. Winter temperatures vary between 23.4°C and 5.2° C respectively.



4.2 CLIMATE

The climate of Dehradun is moderate due to its location at the foot of the Himalayas. The climate of Dehradun is the same as of a North Indian City i.e, cool winters, warm summers, rainy monsoons and a balmy spring.

The climate of Dehradun also depends upon the altitude, the more high you go, the more cold you will feel. Summer temperatures do not go too high though in winter, the temperature sometimes falls down below the freezing point. During the summers, the temperature ranges between 36°C and 16.7°C. During the summers, the temperature ranges between 36°C and 16.7°C. In winters, the temperature lies in between 23.4°C and 5.2°C.

The other significant aspect of the climate of Dehradun is the monsoon. Dehradun gets an average rainfall of 2073.3mm annually. Dehradun receives the rainfall in between June and September. Though in December and January it receives winter rainfall. But the maximum rainfall is recorded in between July and August.

Given below is the chart that shows the climate of Dehradun in all the months :

Month	Rainfall (mm)	Relative Humidity (%)	Maximum Temperature	Minimum Temperature	Average Temperature
January	46.9	91	19.3	3.6	10.9
February	54.9	83	22.4	5.6	13.3
March	52.4	69	26.2	9.1	17.5
April	21.2	53	32	13.3	22.7
May	54.2	49	35.3	16.8	25.4
June	230.2	65	34.4	29.4	27.1
July	630.7	86	30.5	22.6	25.1
August	627.4	89	29.7	22.3	25.3

September	261.4	83	29.8	19.7	24.2
October	32.0	74	28.5	13.3	20.5
November	10.9	82	24.8	7.6	15.7
December	2.8	89	21.9	4.0	12.0

4.3 Population and Population Growth of Dehradun

In 1981 and 1991 decades, the decadal change in population of Dehradun was 21.33% and 21.85% respectively. The sudden jump to 39.73 % in the next decade is explained by the fact that in this decade Uttarakhand was made a separate State with Dehradun as its capital. In the decade 1991-01, Dehradun achieved decadal population growth rate of 39.73 %, which was considerably higher than the national average of 21.53 %(3 Directorate of Economics and Statistics, Government of Uttarakhand, Statistical Diary, Uttarakhand,2004- 05) .

Year	Population ('000 persons)	Decadal Growth Rate (%)
1971	166	
1981	211	21.53
1991	270	21.85
2001	448	39.73

Dehradun population growth rate considerably increased in decade 1991-2001 due to its becoming the capital of the newly created state of Uttarakhand. The possibility of its maintaining a relatively high growth rate of population is high due firstly to State's initiative to achieve higher rate of growth of the economy of the State per se and for expansion of the industrial base of Dehradun among some other areas. Besides, the impact of factors like large investments in industries which are expected to be made in the coming years; the planned infrastructure and institutional improvement with financial assistance of the ADB; and the proposed overall development of the town under the Jawaharlal Nehru National Urban Renewal Mission will widen employment opportunities both in secondary and tertiary sectors. These factors together will lead to the already relatively higher growth rate of service sector to attain a still faster growth rate in the decades to come. As this happens, population will attain much faster rate of growth due to large in-migration of workers to this town besides the natural growth of population. As Dehradun started with a low population base of 4.48 lakhs only (2001) its population growth rate in terms of percentage is expected to be faster in the coming decades as a result of its economic factors mentioned above.

On the basis of this understanding, it is assumed that the population of Dehradun will grow at the rate of 4 % per annum for 5 years following 2009, 3.5 % from 2010 to 2014, and 3.0 % from 2015 to 2019. As the base (population) expands, the rate, of growth in terms of percentage will gradually slow down although in absolute numbers population will keep increasing. It is presumed that population growth rate will stabilize at 2.5 to 2.0 % per annum for the next few decades.

4.4 Vehicular distribution in Uttarakhand

ON ROAD VEHICLES IN UTTARAKHAND AS ON 31st March 2009
(http://gov.ua.nic.in/transport/)

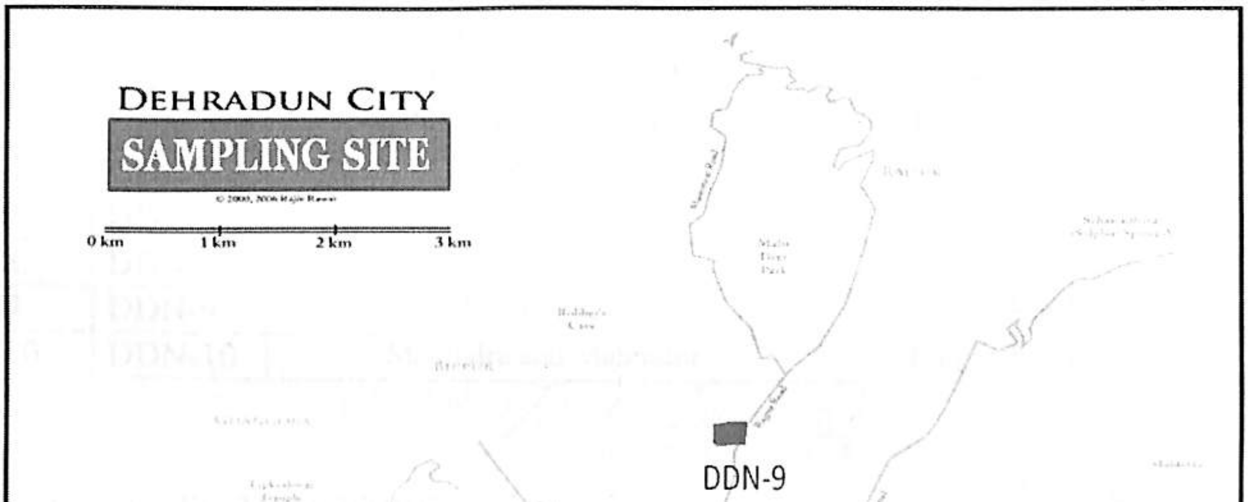
VEHICLE CATEGORY	NUMBER OF VEHICLES
TWO WHEELERS	658097
CARS / JEEP	112623
BUSES	5492
TRUCKS	12205
FOUR WHEELER / DELIVERY VAN	19191
TAXI / MAXI	15427
AUTO TEMPO	10406
TRACTOR	50263
TRAILORS	2983
OTHERS	2055
TOTAL	8,88,742

CHAPTER – 5

METHODOLOGY

Water samples are collected from different Motor Servicing Centre of Doon Valley and the physical and chemical parameters of the samples are analysed in the HSE Laboratory of UPES, Dehradun. The locations of the Servicing Center are kept in mind to cover the entire Doon Valley. The methodology adopted to analyse the above parameters (physical and chemical) are with the best available technique and resources under present circumstances in HSE Laboratory, UPES, Dehradun.

5.1 Site selection



5.2 Sampling

The sampling locations of the Servicing Center are kept in mind to cover the entire Doon Valley.

The sampling locations are as follows:

SL. No	CODE	NAME OF THE SERVICING CENTER	LOCATION
1.	DDN-1	Bajaj Servicing Center	Premnagar
2.	DDN-2	Hyundai Service Center	Prince Chowk
3.	DDN-3	Oberoi Motors Workshop	Majra
4.	DDN-4	Chevrolet Workshop	Transport Nagar
5.	DDN-5	Mohit Auto Service Center	Rajpur Road
6.	DDN-6	Rohan Motors	Chakrata Road
7.	DDN-7	Hyundai Workshop	Haridwar Road
8.	DDN-8	Roadways Workshop	Old ISBT
9.	DDN-9	Mayur Auto	Rajpur Road
10.	DDN-10	Mahindra and Mahindra	Kargi Chowk

5.3 LABORATORY WORK

Analysis of Samples:

The water samples collected from above mentioned sampling locations were analysed for following physicochemical parameters:

Physical assessment

- Temperature
- Total suspended solids (TSS)
- Total dissolved solids (TDS)
- Conductivity

Chemical assessment

- pH
- Total Hardness (calcium carbonate)
- Dissolved Oxygen (DO)
- Iron
- Sodium
- Chloride
- Potassium
- Magnesium
- Alkalinity (bicarbonates)
- Calcium
- Oil and Grease

Characterization of the sites:

The purpose of site characterization is to determine the exact location, hydrocarbon contaminant concentration, and extent of the contaminated zone and also to evaluate the potential for the contaminants to migrate from the sites. The best site for the study is identified as the Motor Servicing Center at various places of Dehradun Valley.

Alkalinity:

Alkalinity is a measure of the buffering capacity of water, or the capacity of bases to neutralize acids. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution from rainfall or wastewater. Alkalinity does not refer to pH, but instead refers to the ability of water to resist change in pH. The presence of buffering materials help neutralize acids as they are added to the water. These buffering materials are primarily the bases bicarbonate (HCO_3^-), and carbonate (CO_3^{2-}), and occasionally hydroxide (OH^-), borates, silicates, phosphates, ammonium, sulfides, and organic ligands.

Principle :

Alkalinity is measured by titration. An acid of known strength (the titrant) is added to a volume of a treated sample of water. The volume of acid required to bring the sample to a specific pH level reflects the alkalinity of the sample. The pH end point is indicated by a color change.

Chloride:

Chlorides are salts resulting from the combination of the gas chlorine with a metal. Some common chlorides include sodium chloride (NaCl) and magnesium chloride (MgCl2). Chlorine alone as Cl2 is highly toxic and it is often used as a disinfectant. In combination with a metal such as sodium it becomes essential for life. Small amounts of chlorides are required for normal cell functions in plant and animal life.

Principle : Chloride is determined in natural or slightly alkaline solution by titration with standard silver nitrate using potassium chromate as a indicator. Silver chloride is quantitatively precipitated before red silver chromate is formed.

Total Hardness:

Principle: In alkaline conditions, EDTA (Ethylene-diamine tetra acetic acid) and its sodium salts react with cations forming a soluble chelated complex when added to a solution. If a small amount of dye such as Eriochrome black-T is added to an aqueous solution containing calcium and magnesium ions at alkaline pH of 10.0 ± 0.1, it forms wine red colour. When EDTA is added as a titrant, all the calcium and magnesium ions in the solution gets complexed resulting in a sharp colour change from wine red to blue, marking the end point of the titration. Hardness of water prevents lather formation with soap rendering the water unsuitable for bathing and washing. It forms scales in boilers, making it unsuitable for industrial usage. At higher pH>12.0, Mg^{++} ion precipitates with only Ca^{++} in solution. At this pH, murexide indicator forms a pink color with Ca^{++} ion. When EDTA is added, Ca^{++} gets complexed resulting in a change from pink to purple indicating end point of the reaction.

Ca concentration and Ca Hardness:

Principle: When EDTA (Ethylene-diamine tetra acetic acid) is added to the water containing calcium and magnesium, it combines first with calcium. Calcium can be determined directly with EDTA when pH is made sufficiently high such that the magnesium is largely precipitated as hydroxyl compound (by adding NaOH and iso-propyl alcohol). When murexide indicator is added to the solution containing calcium, all the calcium gets complexed by the EDTA at pH 12-13. The end point is indicated from a colour change from pink to purple.

Mg concentration and Mg Hardness:

Principle : Magnesium is a relatively abundant element in the earth's crust, ranking eighth in abundance among the elements. It is found in all natural waters and its source lies in rocks, generally present in lower concentration than calcium. It is also an important element contributing to hardness and a necessary constituent of chlorophyll. Its concentration greater than 125 mg/L can influence cathartic and diuretic actions.

Principle: Magnesium hardness can be calculated from the determined total hardness and calcium hardness.

Na and K:

Sodium and Potassium

Sodium is present in number of minerals, the principle one being rock salt (NaCl). The increase pollution of surface and ground water during the past has resulted in a substantial increase in of the sodium content of drinking water in different region of the world. Sewage industrial effluent , sea water intrusion in coastal area and the use of sodium compound for corrosion control and water softening process all contribute to sodium concentration in water because of high solubility of sodium salts and minerals. Sodium level in ground water vary widely but normally range between 6 to 130 mg/l . In surface water sodium concentration may be less than 1 mg/l or exceed 300mg/l depending upon the geographical area.

The estimation of sodium and potassium is based on the emission spectroscopy, which deals with the excitation of electrons from ground state to higher energy state and coming back to its original state with the emission of light.

Principle : The sample solution is sucked by atomizer under controlled condition. The radiation form flame enters a dispersing device inorder to isolate the desired region of the spectrum. The intensity of isolated radiation can be measured by photo tube. After carefully calibration the photometer with solution of known composition and concentration, it is possible to co-relate the intensity of a given spectral line of unknown with the amount of an element present that emit a particular radiation.

Principle of Flame Photometry:

Flame photometry based on the fact that compound of alkali and alkaline earth metals can be thermally excited in a low temperature flame and when the atom return to the ground state they emit radiation which lies mainly in the visible region of the spectrum. Each element emits radiation at a wavelength specific to that element.

e.g Na 589 nm, K 766 nm , Ca 622 nm, Li 670 nm

Over a certain range of concentration the intensity of the emitted radiation is directly proportional 1 to the number of atom returning to the ground state. This in turn is proportional to the absolute quantity of species volatilizes in the flame i.e light emitted is proportional to the sample concentration. The light emitted by the element at its characteristics wavelength is isolated by an optical filter and the intensity of that light is measured by photo detector which provide a signal proportional to the sample concentration. Such an electric signal is processed with the help of Analog to Digital concertor and the microprocessor. The concentration of sodium and potassium are displayed in ppm.

pH:

Handling of pH meter : The one electrode is dipped in N/10 HCl overnight, so that the electrode get charged properly. Note down the room temperature and set the pH meter at this temperature.

The pH meter is switched in downward direction. The pH meter is allowed to warm up for atleast 15 to 20 minutes in summer and 30-40 minutes in winter by keeping power on and the instrument is standby so that a pH meter attain a proper condition for measurement.

In the mean time the electrode is taken out from N/10 HCl and washed properly with distill water both the electrode are dried carefully with the help of filter paper.

Total suspended solid (TSS):

Procedure :

- Take a dried Whatman filter paper No-42 and write identification number on it.
- Weight the filter paper and note the weight against its number.
- Take 100 ml of the sample while stirring vigorously into a conical flask.
- Pipette 50 ml of conical flask and filter it using the previously weighted filter paper.
- Place the filter paper in oven at 105 °C till all the water content of the beaker is evaporated.

- Take out the dried filter paper from the oven and allow it to cool by keeping it in the desicator.
- After filter paper is cooled to ambient temperature , weight it and note down the reading.

Total dissolve solids (TDS):

Procedure :

- Take 100 ml of well shaken sample and filter it by using Whatman filter paper No-42 to get filtrate more then 50 ml into a measuring cylinder.
- Take a clean dried beaker of glass and write identification number on it.
- Weight the beaker and note the weight against its number.
- Pipette 50 ml of filtrate from the measuring cylinder into the weighted beaker.
- Keep the beaker in the oven at 105 ^{o}C till all the water content of the beaker evaporated.
- Take out the dried beaker from oven and allow it to cool by keeping it in desiccators.
- After the beaker is cooled to ambient temperature , weight it ad note the reading.

Oil and Grease:

Principle : Dissolved or emulsified Oil and Grease is extracted from water by intimate contact with petroleum ether or hexane or tricholoflouro ethane.

Procedure :

1. Take 250 ml sample in separating funnel.
2. Add 10 ml H_2SO_4 and 30 ml petroleum ether.
3. Shake Well
4. Wait for separate two distinct layers.
5. Discard lower layer.
6. Filter Petroleum ether into preweighed dish from water bath.
7. Evaporate petroleum ether with the help of water bath.
8. Weigh dish

Calculation :

Oil and grease in mg/l = $(W2-W1) \times 1000 \times 1000 / V$

Where W1 = Initial weight of dish

W2 = Final Weight of dish

V = Volume of sample takens

CHAPTER - 6

RESULT AND ANALYSIS

Table 2: Water Analysis Report:

Location : Bajaj Servicing Center, Prem Nagar

Sl. No.	Parameters	Results
1.	Temperature	33.4°C
2.	Conductivity	729
3	TDS	488.43 mg/L
4.	TSS	11 mg/L
5.	pH	7.8
6.	DO	6.5 mg/L
7.	Alkalinity	366 mg/L
8.	Ca	96.72 mg/L
9.	Mg	62.81 mg/L
10	Total Hardness	500 mg/L
11	Ca Hardness	241.5 mg/L
12	Cl	24.81 mg/L
13	Na	35.7 mg/L
14	K	2.3 mg/L
15	Oil and Grease	39 mg/L

Table 3: Water Analysis Report

Location : Hyundai Servicing Center, Prince Chowk

Sl. No.	Parameters	Results
1.	Temperature	33.7°C
2.	Conductivity	877
3	TDS	587.59 mg/L
4.	TSS	12 mg/L
5.	pH	7.5
6.	DO	6.7 mg/L
7.	Alkalinity	298.9 mg/L
8.	Ca	96.72 mg/L
9.	Mg	50.66 mg/L
10	Total Hardness	450 mg/L
11	Ca Hardness	241.5 mg/L
12	Cl	54.59 mg/L
13	Na	32.9 mg/L
14	K	2.2 mg/L
15	Oil and Grease	56 mg/L

Table 4: Water Analysis Report

Location : Oberoi Motors, Majra

Sl. No.	Parameters	Results
1.	Temperature	33.5°C
2.	Conductivity	995
3	TDS	666.65 mg/L
4.	TSS	27 mg/L
5.	pH	7.9
6.	DO	6.3 mg/L
7.	Alkalinity	457.5 mg/L
8.	Ca	142.97 mg/L
9.	Mg	46.89 mg/L
10	Total Hardness	550 mg/L
11	Ca Hardness	357 mg/L
12	Cl	54.59 mg/L
13	Na	32.5 mg/L
14	K	11 mg/L
15	Oil and Grease	48 mg/L

Table 5: Water Analysis Report

Location : Mohit Auto, Rajpur Road

Sl. No.	Parameters	Results
1.	Temperature	34.0°C
2.	Conductivity	950
3	TDS	636.5 mg/L
4.	TSS	21 mg/L
5.	pH	7.2
6.	DO	6.5 mg/L
7.	Alkalinity	402.6 mg/L
8.	Ca	126.15 mg/L
9.	Mg	57.1 mg/L
10	Total Hardness	550 mg/L
11	Ca Hardness	315 mg/L
12	Cl	49.63 mg/L
13	Na	9.7 mg/L
14	K	7.9 mg/L
15	Oil and Grease	20 mg/L

Table 6: Water Analysis Report

Location : Chevrolet Servicing Center, Transport Nagar

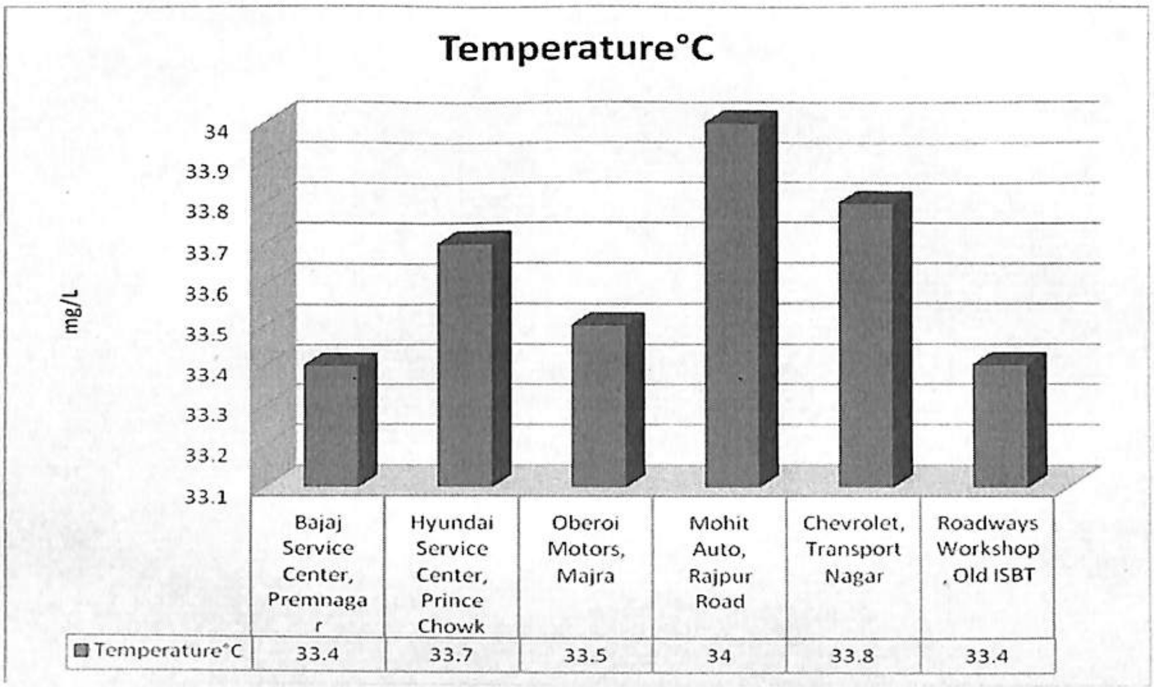
Sl. No.	Parameters	Results
1.	Temperature	33.8°C
2.	Conductivity	643
3	TDS	430.81 mg/L
4.	TSS	11 mg/L
5.	pH	7.5
6.	DO	6.8 mg/L
7.	Alkalinity	353.8 mg/L
8.	Ca	113.54 mg/L
9.	Mg	64.75 mg/L
10	Total Hardness	520 mg/L
11	Ca Hardness	283.5 mg/L
12	Cl	44.66 mg/L
13	Na	11.1 mg/L
14	K	1.3 mg/L
15	Oil and Grease	32 mg/L

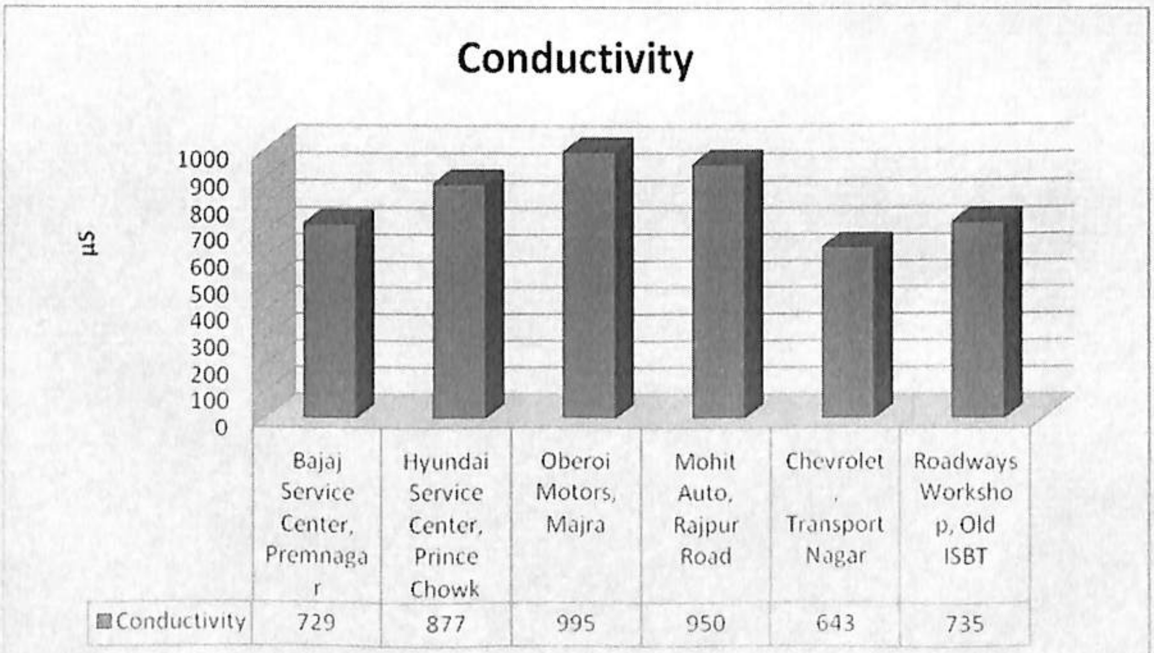
Table 7: Water Analysis Report

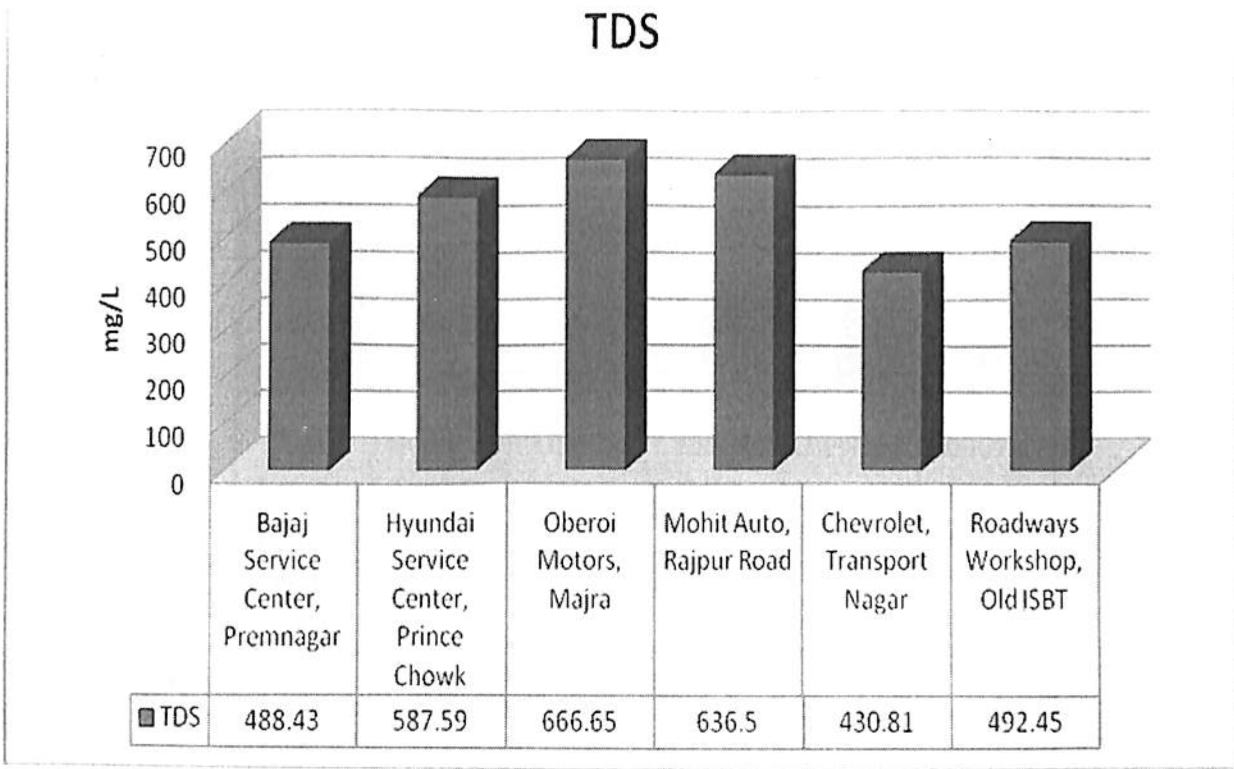
Location : Roadways Workshop, Old ISBT, Haridwar Road

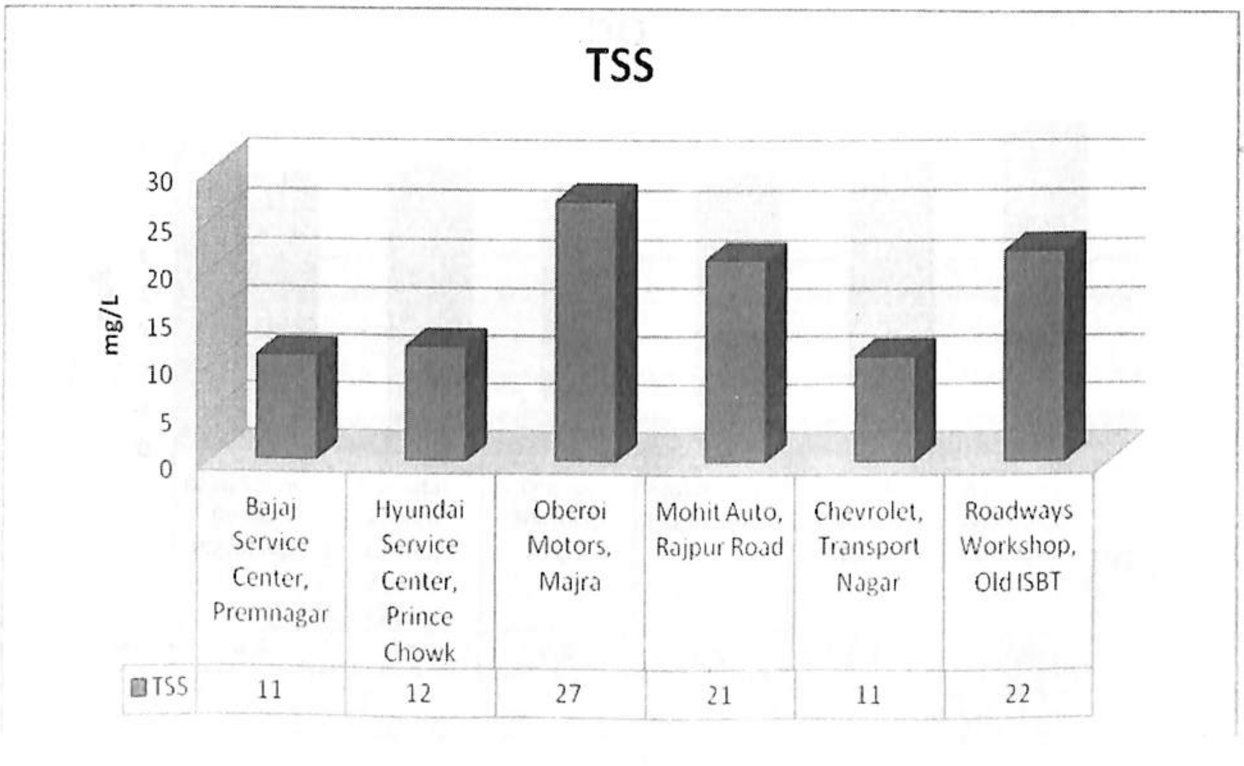
Sl. No.	Parameters	Results
1.	Temperature	33.4°C
2.	Conductivity	735
3	TDS	492.45 mg/L
4.	TSS	22 mg/L
5.	pH	7.6
6.	DO	7.8 mg/L
7.	Alkalinity	361 mg/L
8.	Ca	105 mg/L
9.	Mg	69.86 mg/L
10	Total Hardness	550 mg/L
11	Ca Hardness	262.5 mg/L
12	Cl	34.74 mg/L
13	Na	24 mg/L
14	K	6.8 mg/L
15	Oil and Grease	76 mg/L

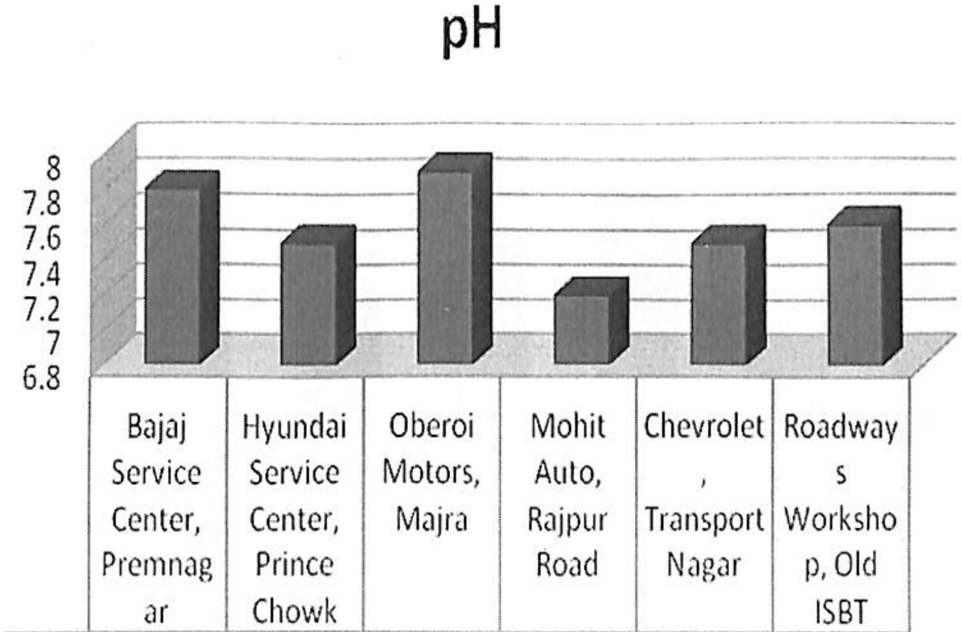
FIGURE 3 : GRAPHICAL REPRESENTATION AND COMPARISON OF ANALYSIS RESULT:



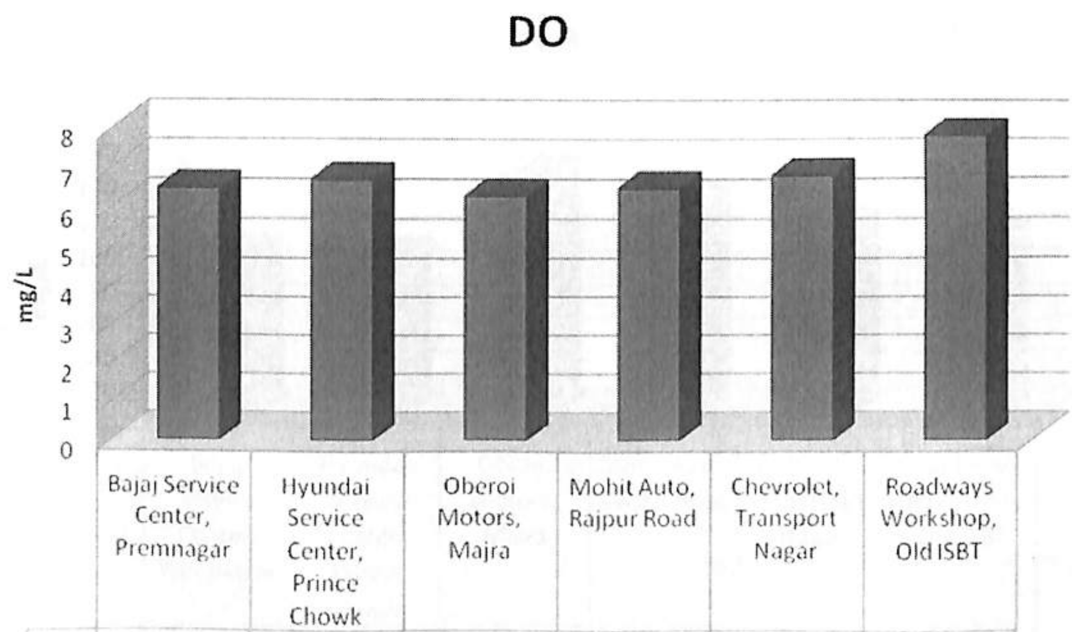



TDS
700
600
500
400
300
200
100
0
mg/L
Bajaj Service Center, Premnagar
Hyundai Service Center, Prince Chowk
Oberoi Motors, Majra
Mohit Auto, Rajpur Road
Chevrolet, Transport Nagar
Roadways Workshop, Old ISBT
TDS
488.43
587.59
666.65
636.5
430.81
492.45

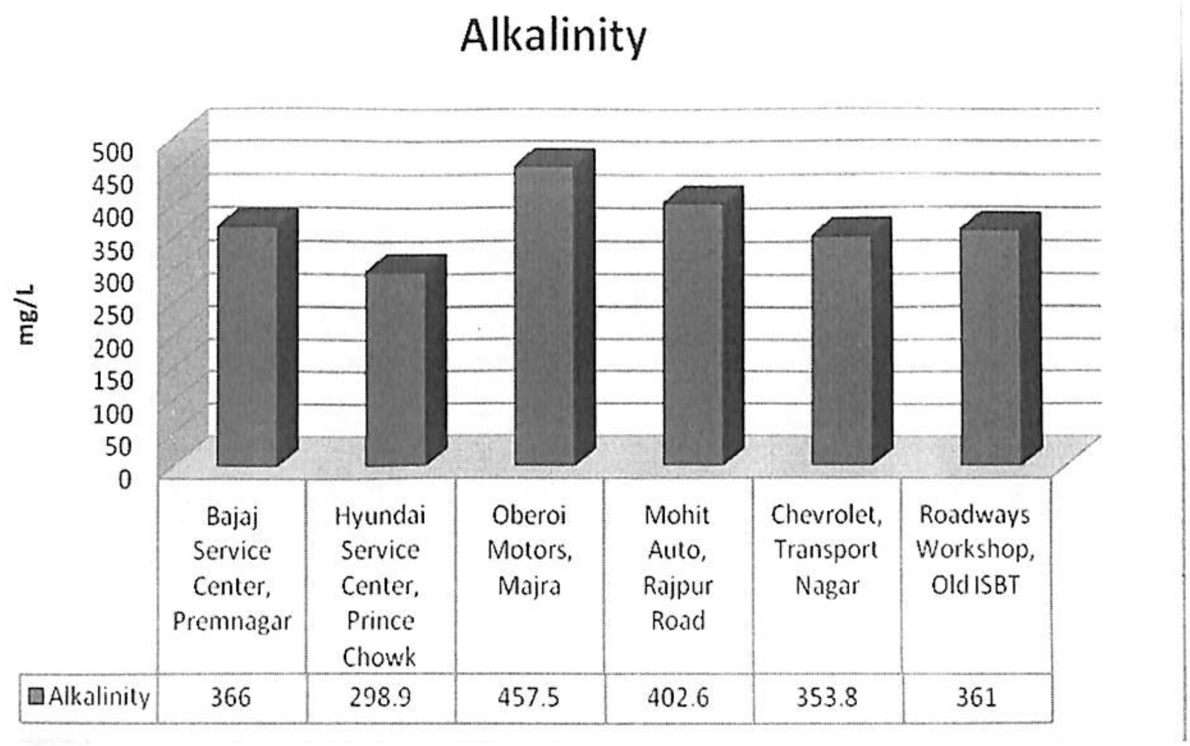

TSS
30
25
20
15
10
5
0
mg/L
Bajaj Service Center, Premnagar
Hyundai Service Center, Prince Chowk
Oberoi Motors, Majra
Mohit Auto, Rajpur Road
Chevrolet, Transport Nagar
Roadways Workshop, Old ISBT
TSS
11
12
27
21
11
22

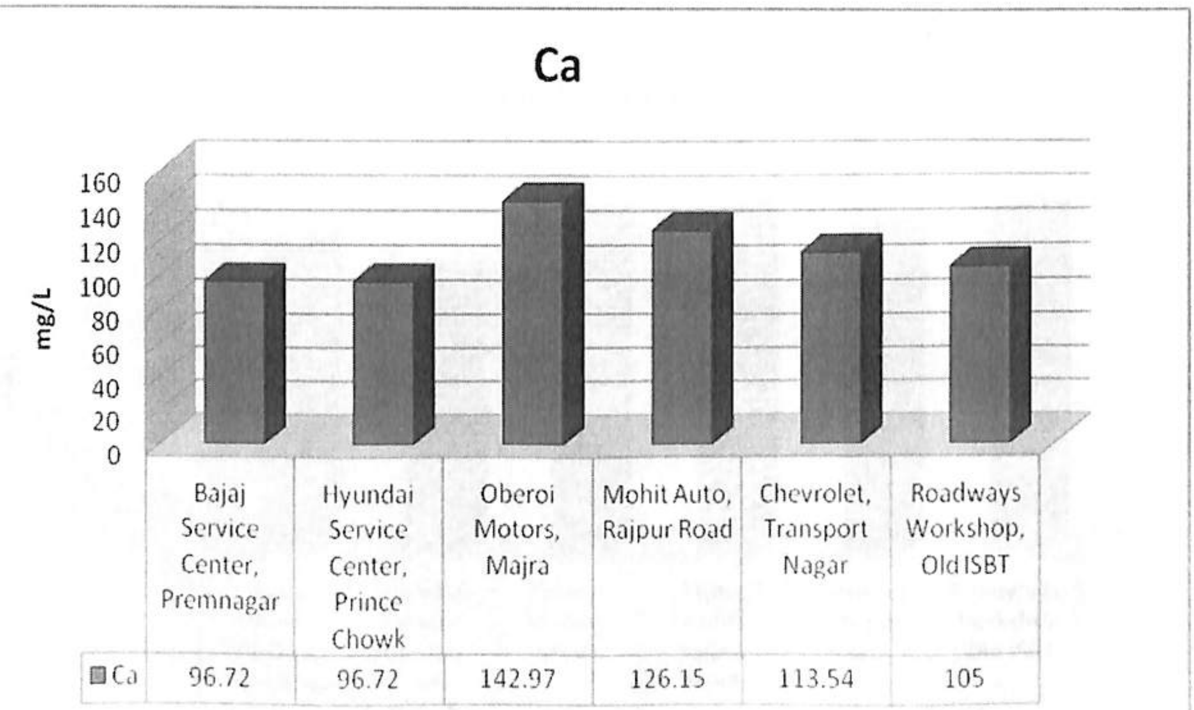


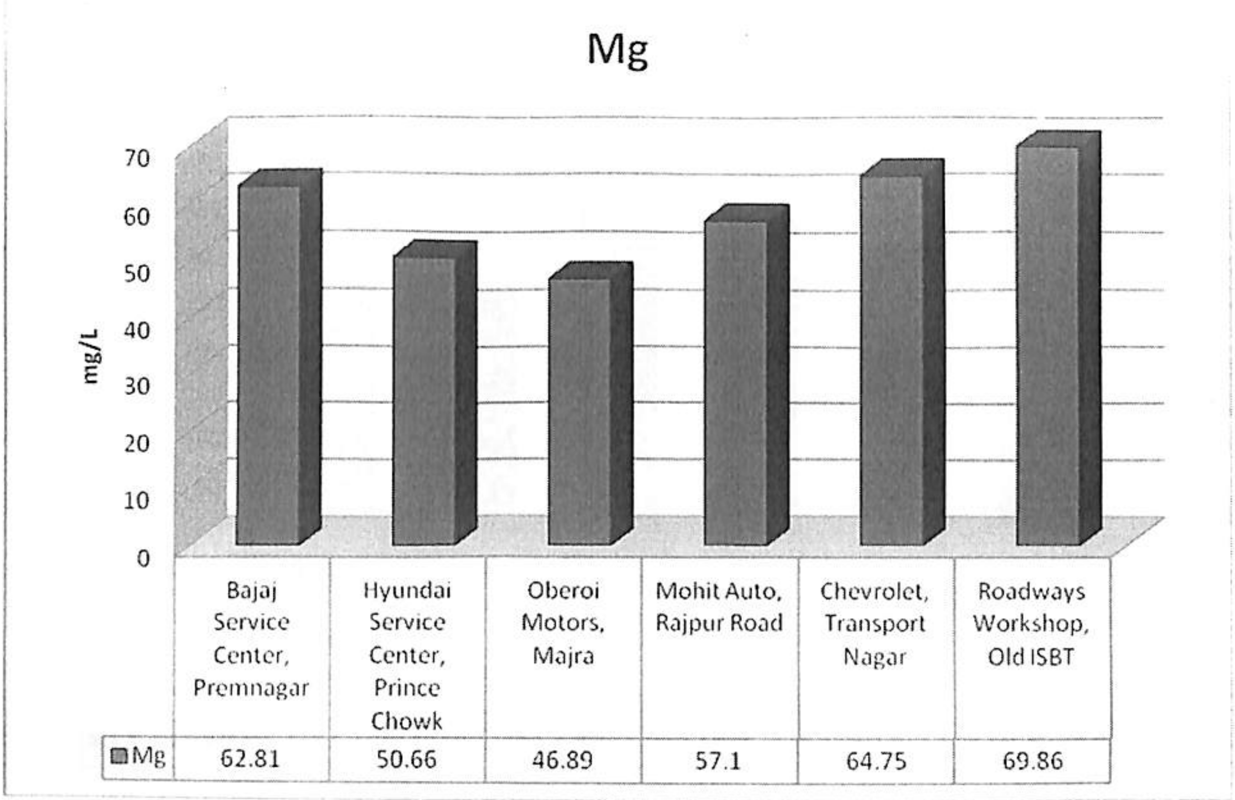
	Bajaj Service Center, Premnagar	Hyundai Service Center, Prince Chowk	Oberoi Motors, Majra	Mohit Auto, Rajpur Road	Chevrolet, Transport Nagar	Roadways Workshop, Old ISBT
pH	7.8	7.5	7.9	7.2	7.5	7.6

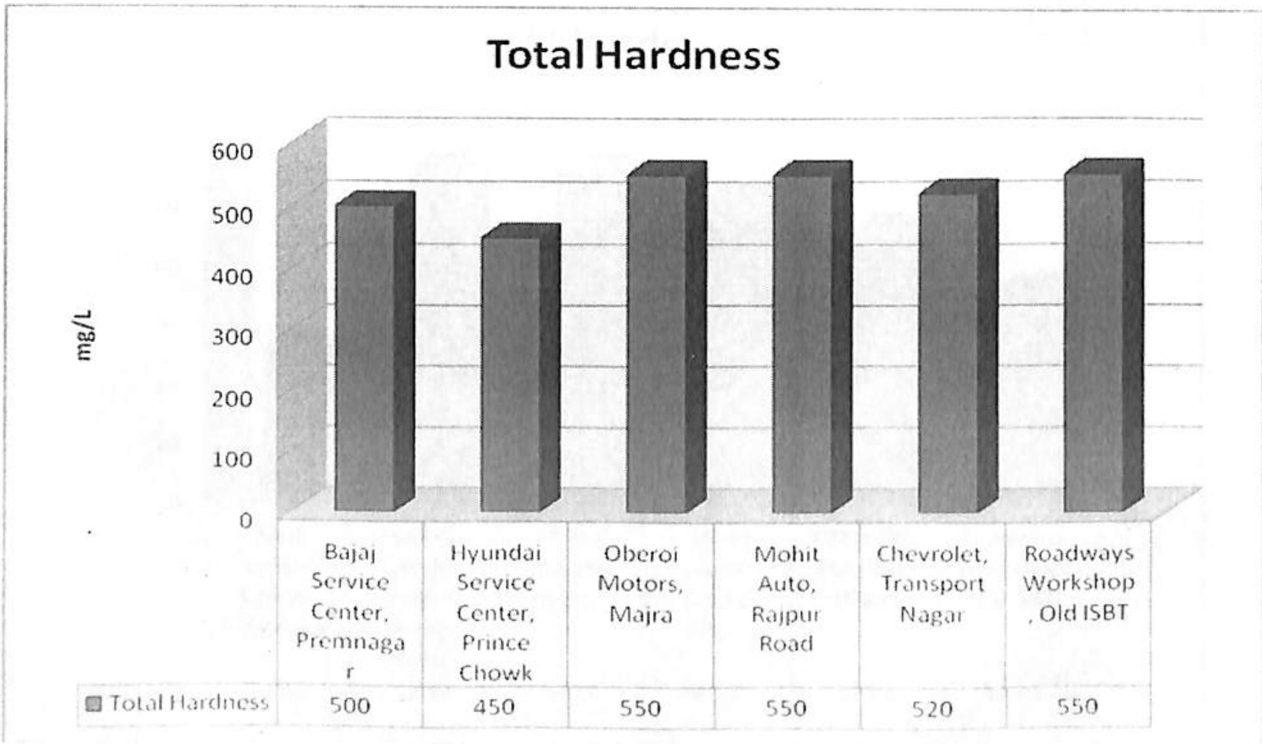


	Bajaj Service Center, Premnagar	Hyundai Service Center, Prince Chowk	Oberoi Motors, Majra	Mohit Auto, Rajpur Road	Chevrolet, Transport Nagar	Roadways Workshop, Old ISBT
DO	6.5	6.7	6.3	6.5	6.8	7.8

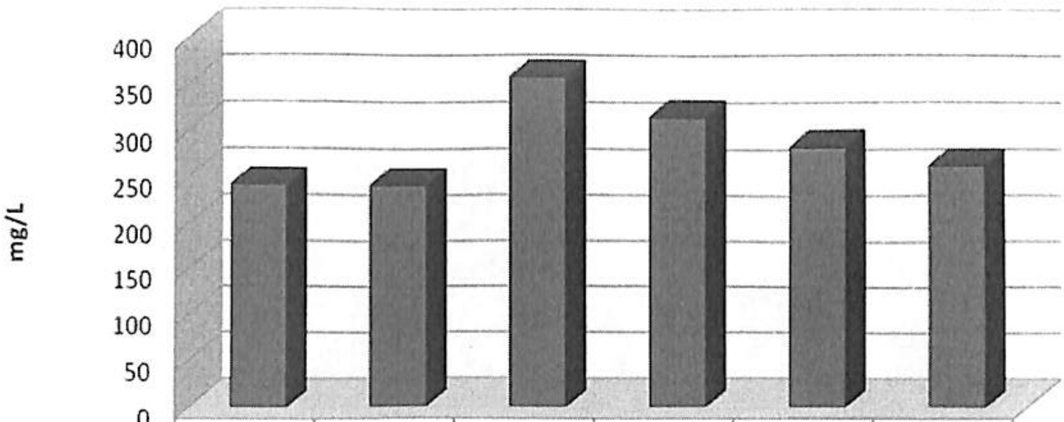

Alkalinity
mg/L
500
450
400
350
300
250
200
150
100
50
0
Bajaj Service Center, Premnagar
Hyundai Service Center, Prince Chowk
Oberoi Motors, Majra
Mohit Auto, Rajpur Road
Chevrolet, Transport Nagar
Roadways Workshop, Old ISBT
Alkalinity
366
298.9
457.5
402.6
353.8
361


Ca
mg/L
160
140
120
100
80
60
40
20
0
Bajaj Service Center, Premnagar
Hyundai Service Center, Prince Chowk
Oberoi Motors, Majra
Mohit Auto, Rajpur Road
Chevrolet, Transport Nagar
Roadways Workshop, Old ISBT
Ca
96.72
96.72
142.97
126.15
113.54
105


Mg
mg/L
70
60
50
40
30
20
10
0
Bajaj Service Center, Premnagar
Hyundai Service Center, Prince Chowk
Oberoi Motors, Majra
Mohit Auto, Rajpur Road
Chevrolet, Transport Nagar
Roadways Workshop, Old ISBT
Mg
62.81
50.66
46.89
57.1
64.75
69.86

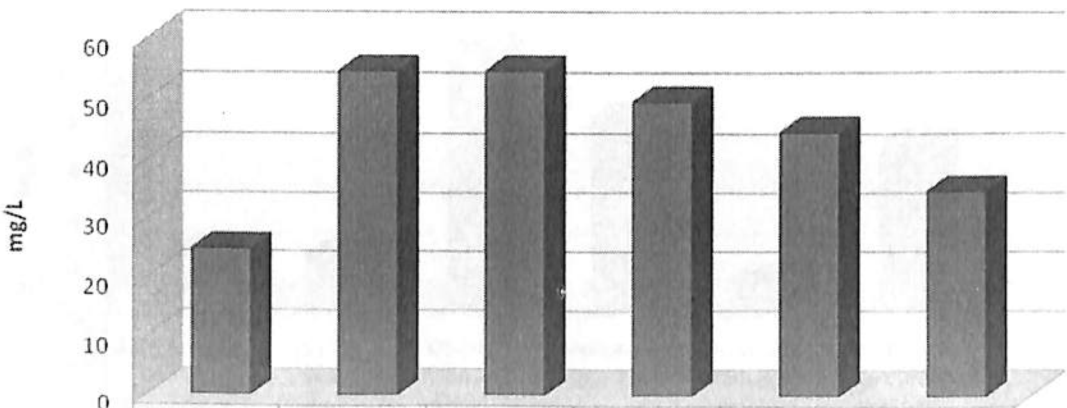

Total Hardness
mg/L
600
500
400
300
200
100
0
Bajaj Service Center, Premnaga r
Hyundai Service Center, Prince Chowk
Oberoi Motors, Majra
Mohit Auto, Rajpur Road
Chevrolet, Transport Nagar
Roadways Workshop , Old ISBT
Total Hardness
500
450
550
550
520
550

Ca Hardness

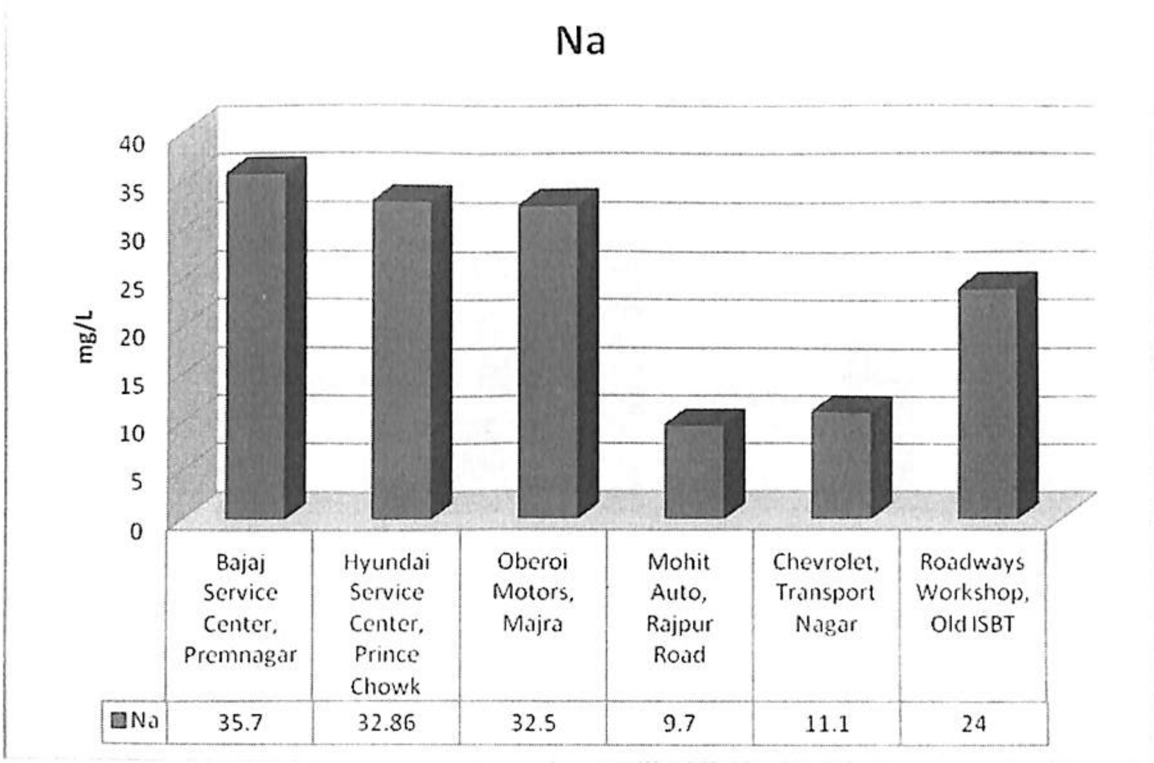


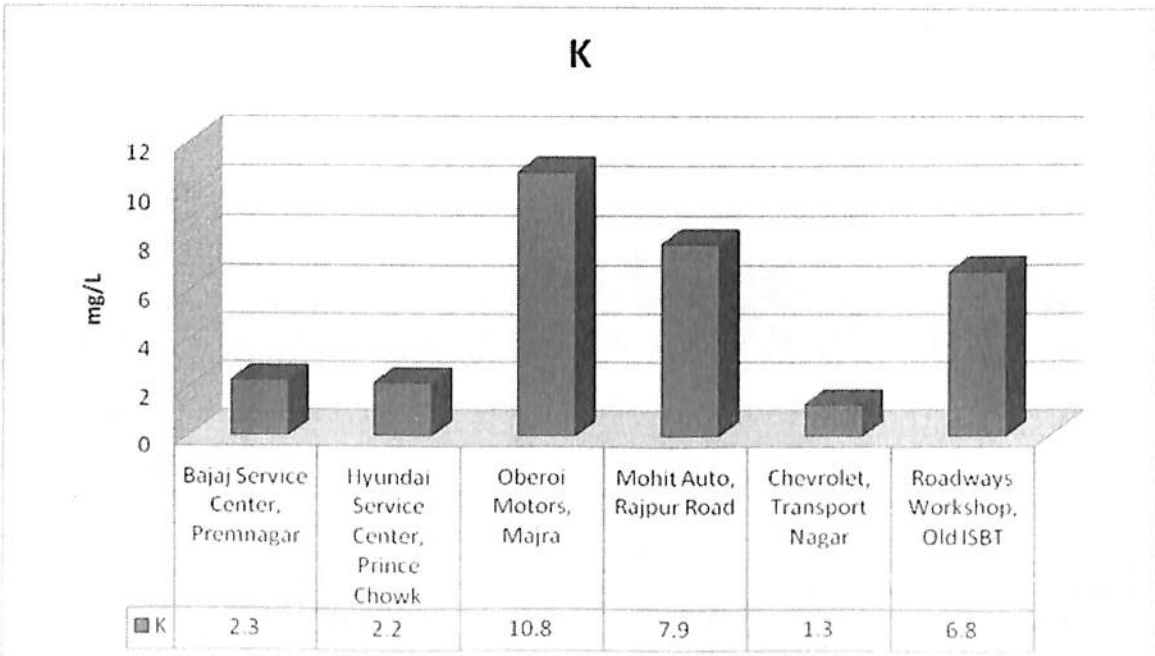
	Bajaj Service Center, Premnagar	Hyundai Service Center, Prince Chowk	Oberoi Motors, Majra	Mohit Auto, Rajpur Road	Chevrolet, Transport Nagar	Roadways Workshop, Old ISBT
Ca Hardness	241.5	241.5	357	315	283.5	262.5

Chloride



	Bajaj Service Center, Premnagar	Hyundai Service Center, Prince Chowk	Oberoi Motors, Majra	Mohit Auto, Rajpur Road	Chevrolet, Transport Nagar	Roadways Workshop, Old ISBT
Chloride	24.81	54.59	54.59	49.63	44.66	34.74


Na
mg/L
40
35
30
25
20
15
10
5
0
Bajaj Service Center, Premnagar
Hyundai Service Center, Prince Chowk
Oberoi Motors, Majra
Mohit Auto, Rajpur Road
Chevrolet, Transport Nagar
Roadways Workshop, Old ISBT
Na
35.7
32.86
32.5
9.7
11.1
24


K
mg/L
12
10
8
6
4
2
0
Bajaj Service Center, Premnagar
Hyundai Service Center, Prince Chowk
Oberoi Motors, Majra
Mohit Auto, Rajpur Road
Chevrolet, Transport Nagar
Roadways Workshop, Old ISBT
K
2.3
2.2
10.8
7.9
1.3
6.8

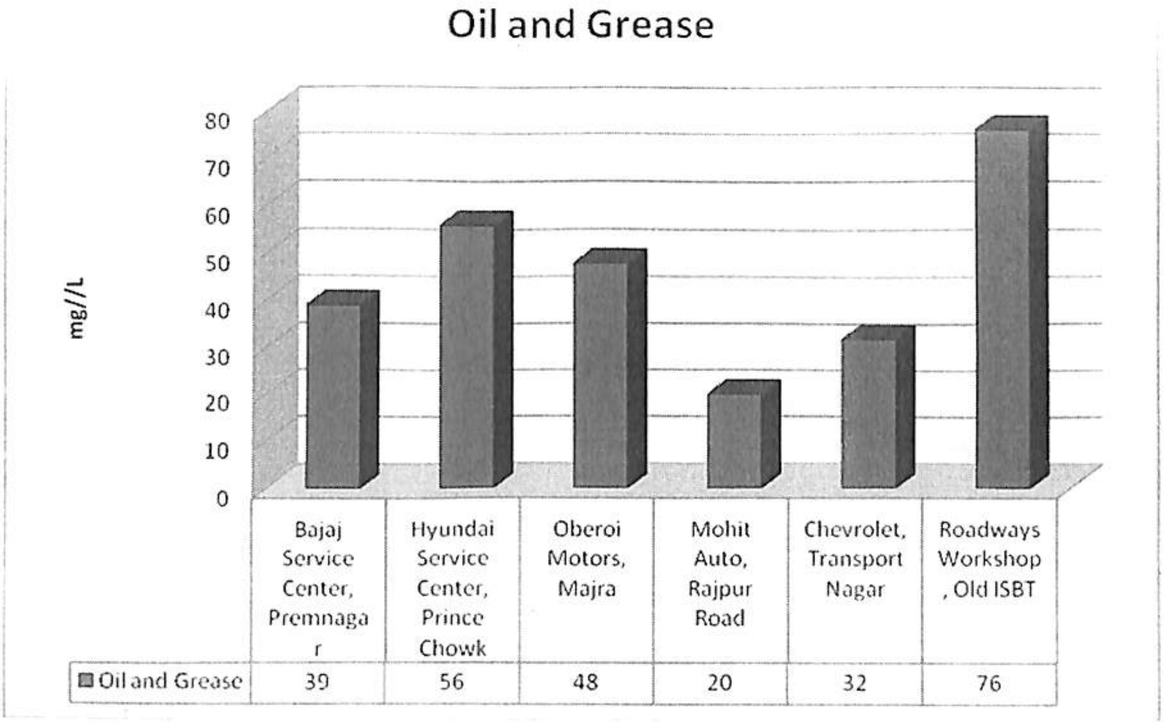
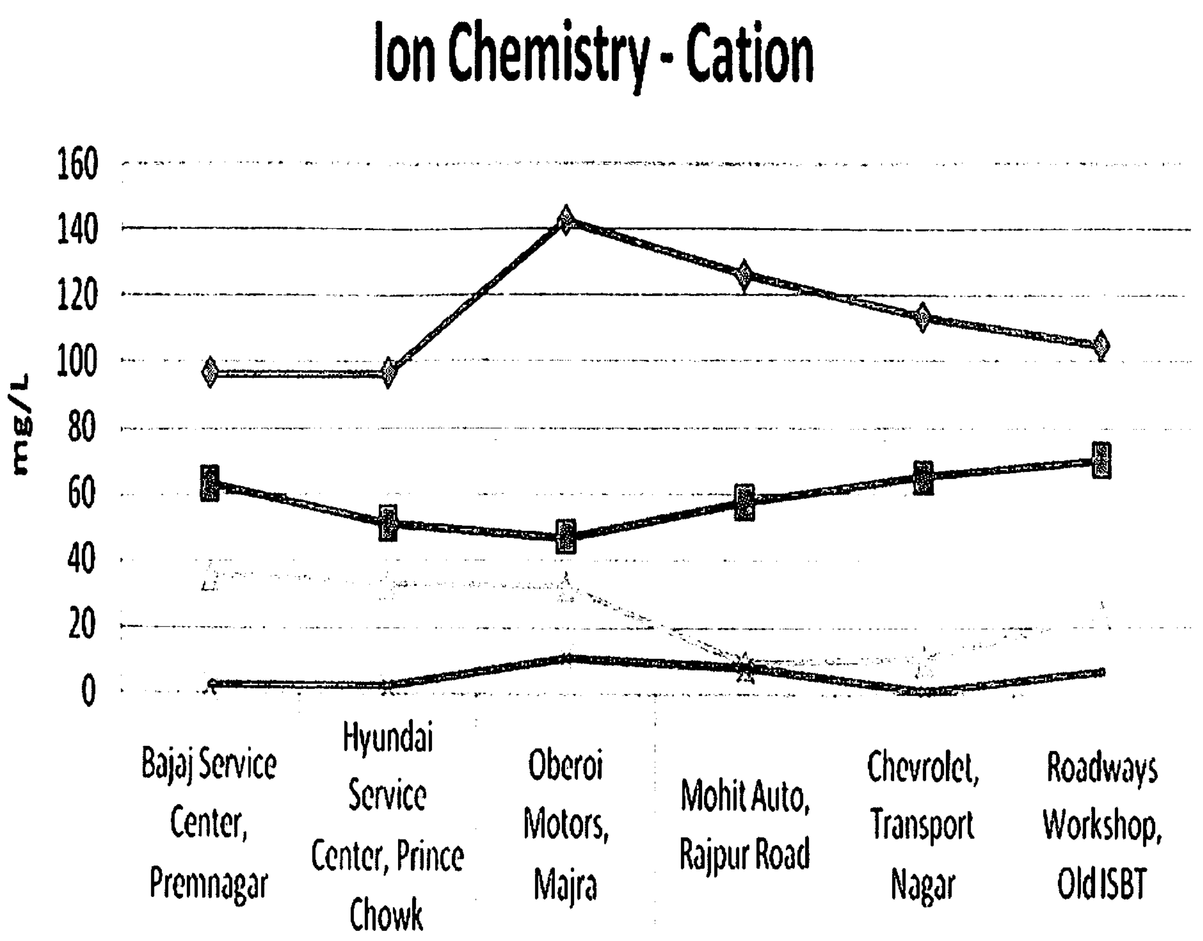

Oil and Grease
mg//L
80
70
60
50
40
30
20
10
0
Bajaj Service Center, Premnagar
Hyundai Service Center, Prince Chowk
Oberoi Motors, Majra
Mohit Auto, Rajpur Road
Chevrolet, Transport Nagar
Roadways Workshop, Old ISBT
Oil and Grease
39
56
48
20
32
76

Figure 4 : Cation distribution



	Bajaj Service Center, Premnagar	Hyundai Service Center, Prince Chowk	Oberoi Motors, Majra	Mohit Auto, Rajpur Road	Chevrolet, Transport Nagar	Roadways Workshop, Old ISBT
Ca	96.72	96.72	142.97	126.15	113.54	105
Mg	62.81	50.66	46.89	57.1	64.75	69.86
Na	35.7	32.86	32.5	9.7	11.1	24
K	2.3	2.2	10.8	7.9	1.3	6.8

Figure 5 : Anion distribution

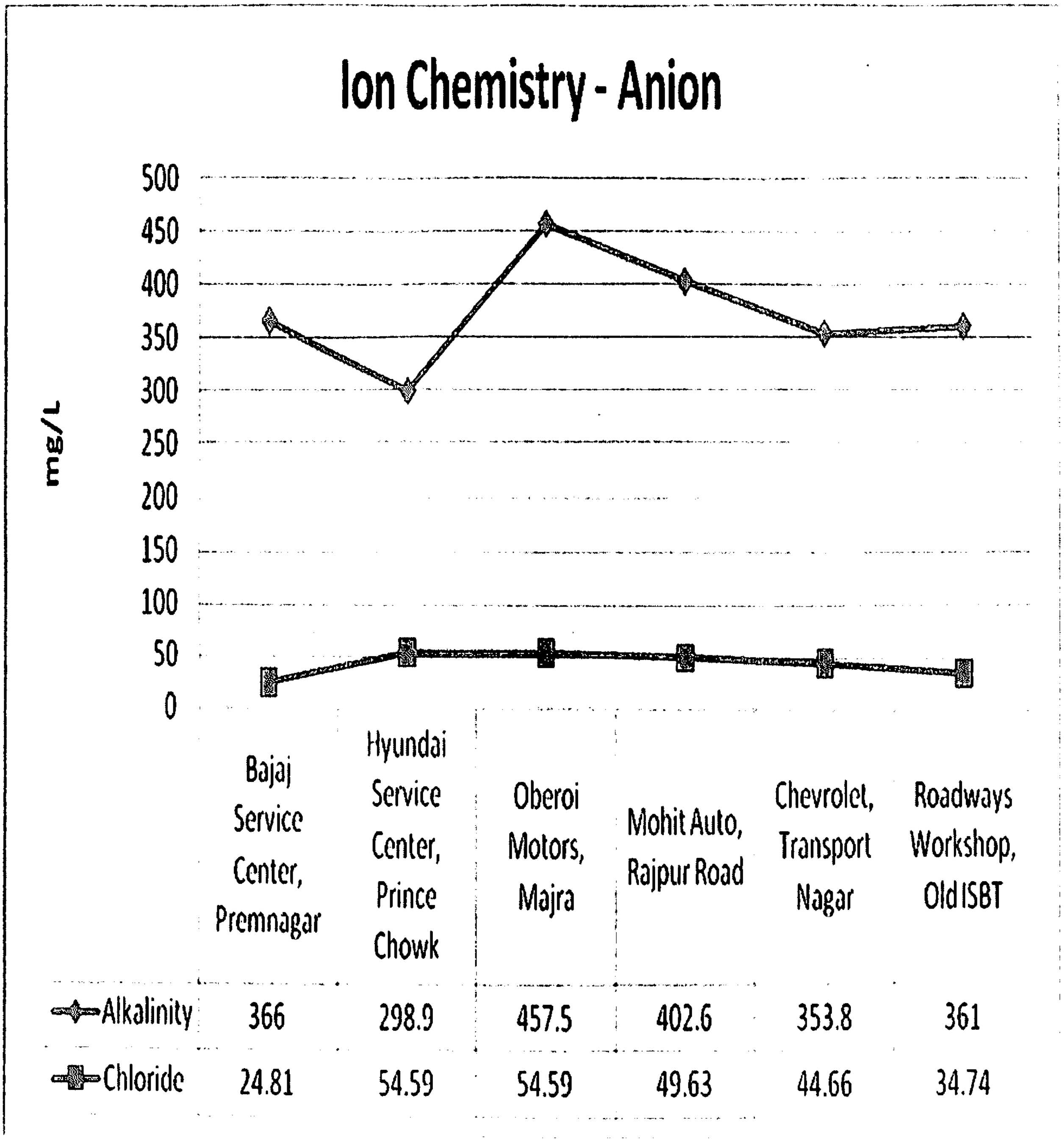
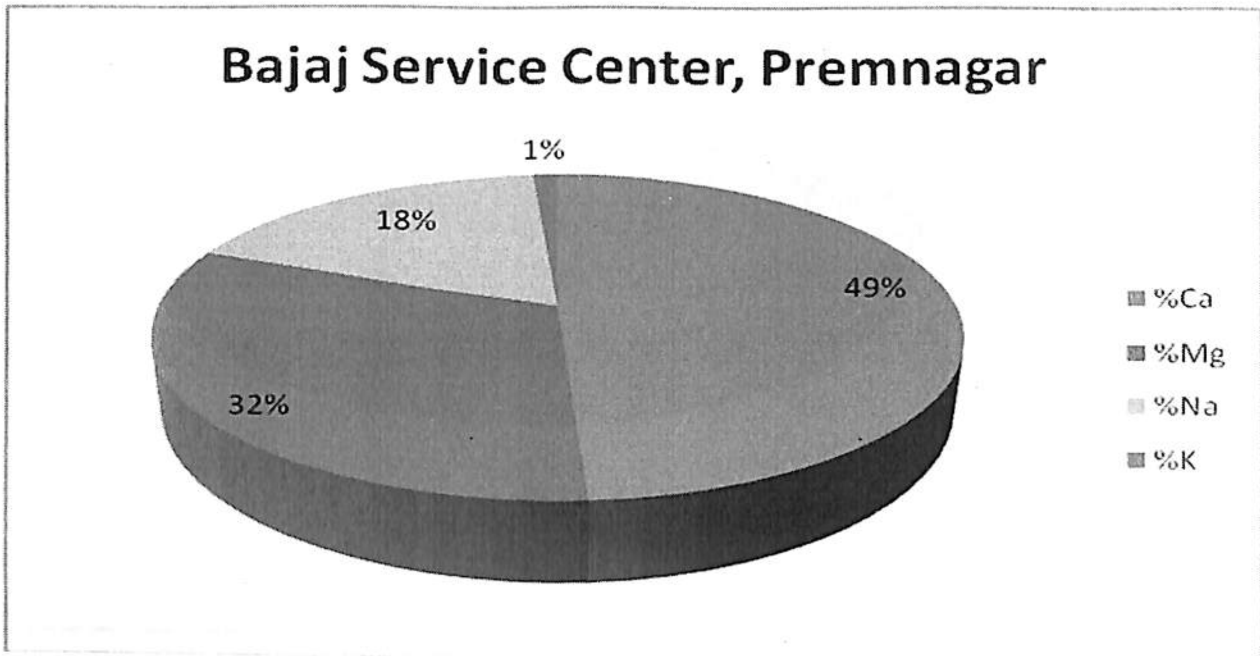
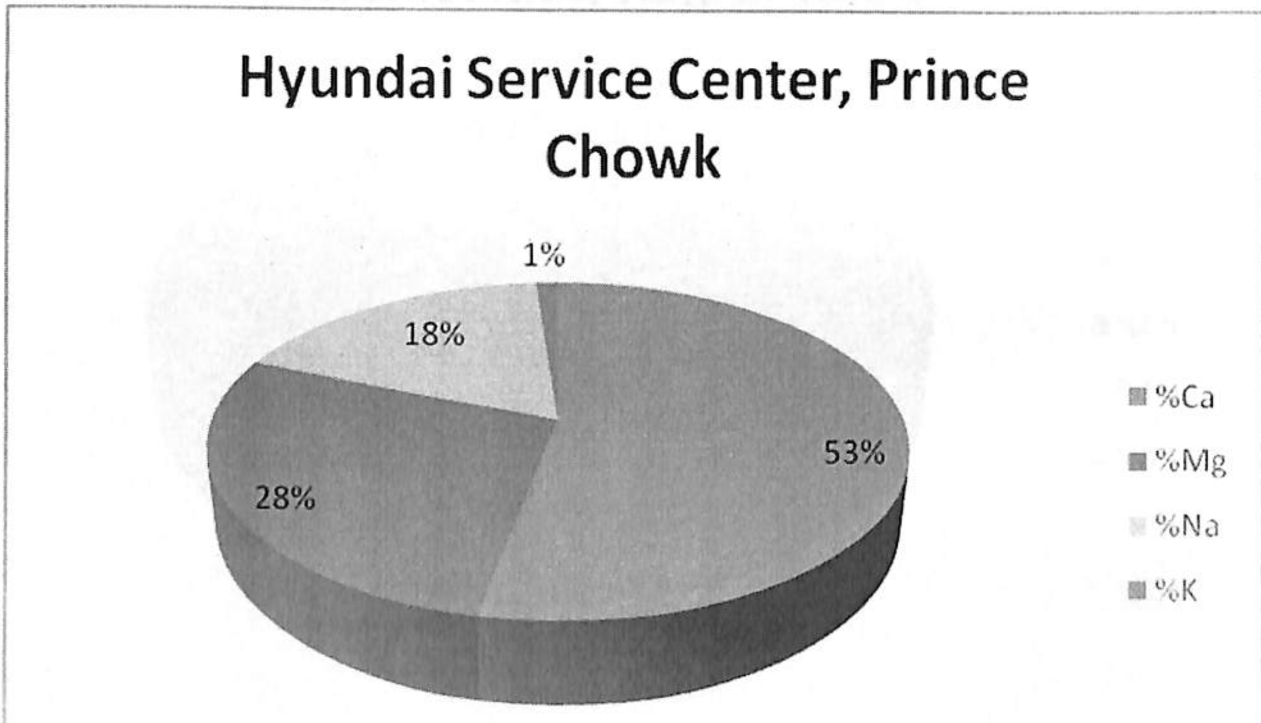
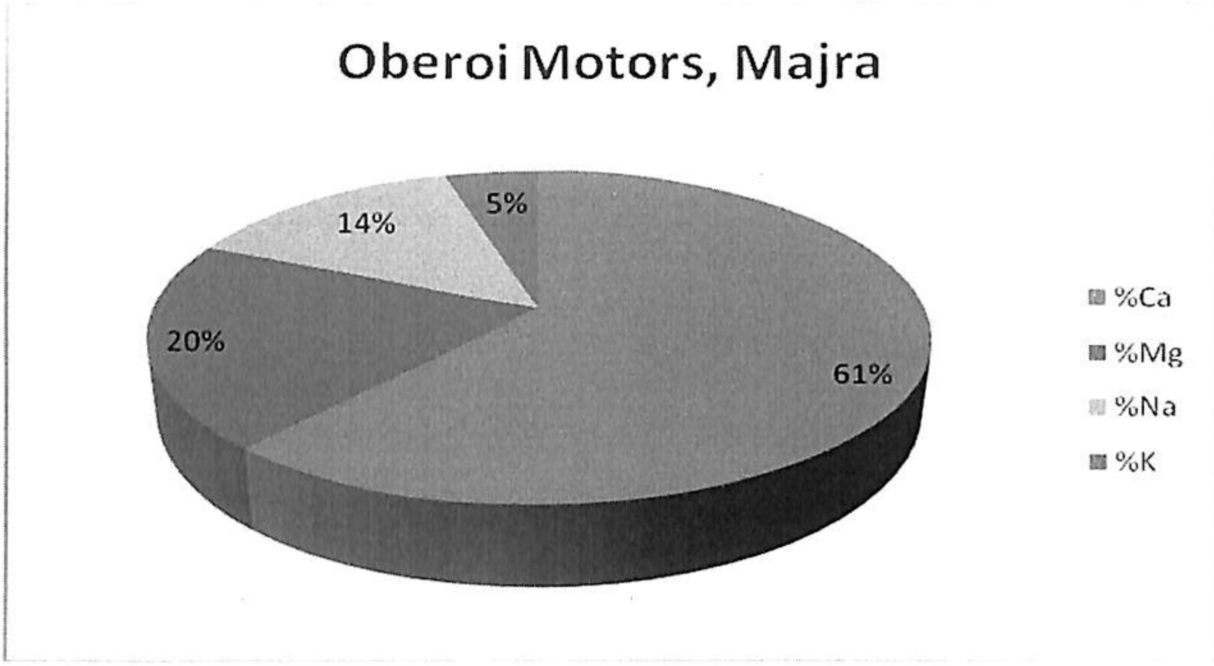
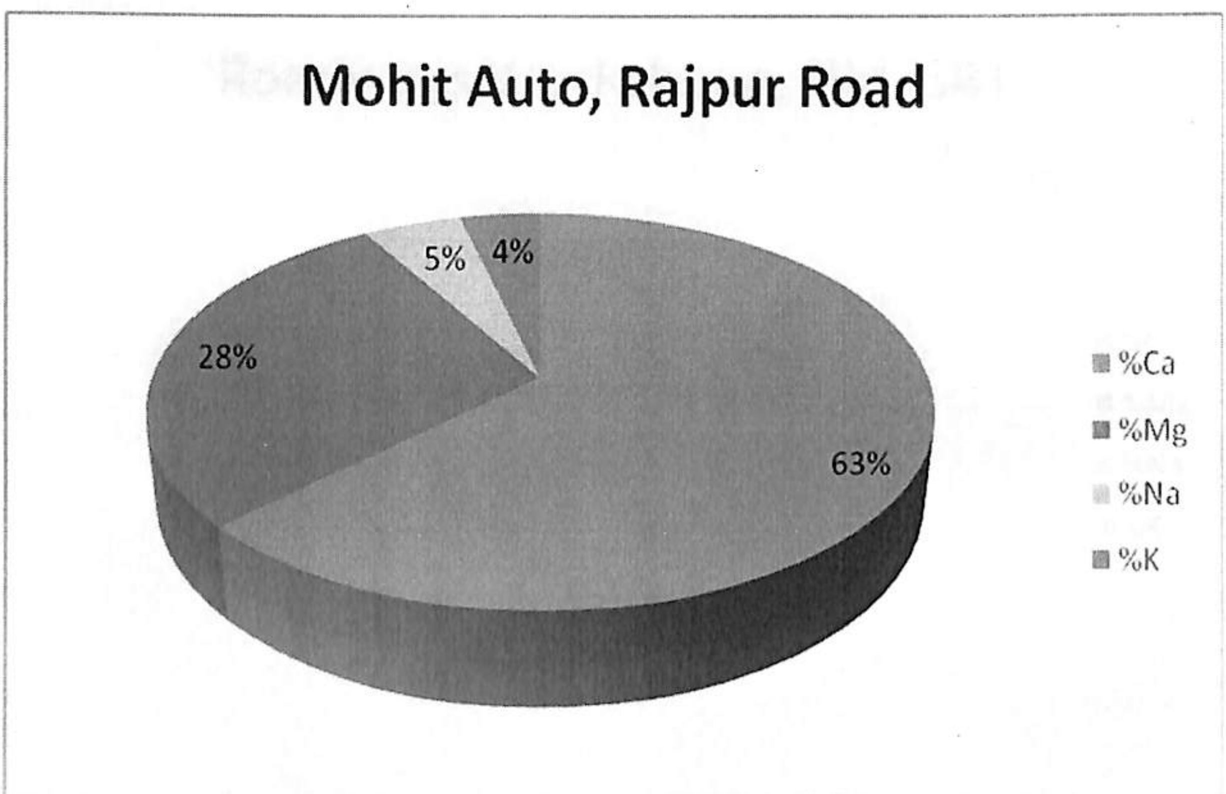


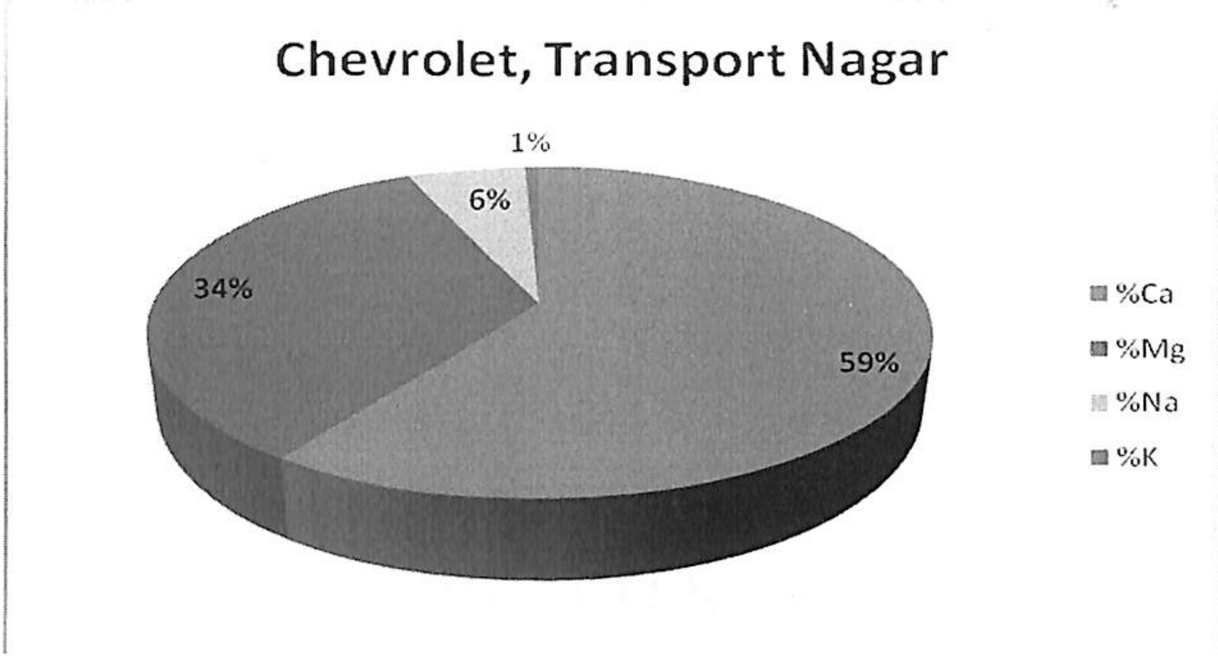
Figure 6: Cation % distribution of each Motor Servicing Center

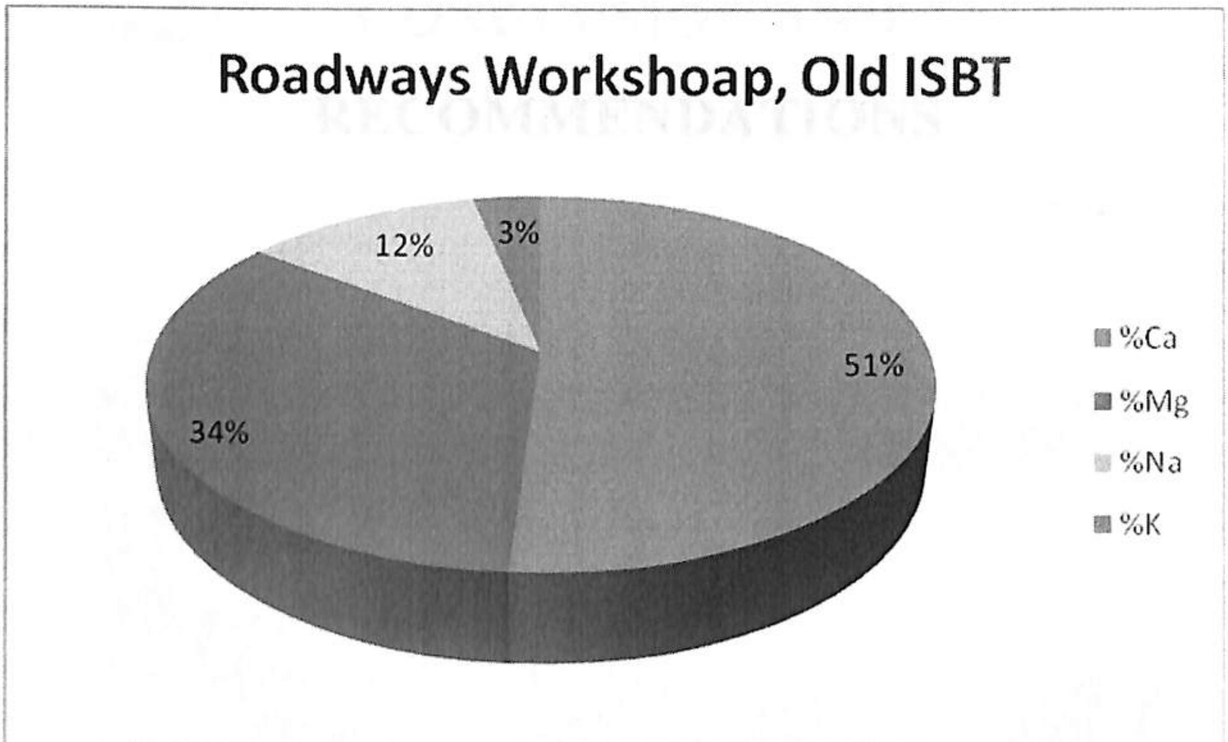





Oberoi Motors, Majra
14%
5%
20%
61%
%Ca
%Mg
%Na
%K


Mohit Auto, Rajpur Road
5%
4%
28%
63%
%Ca
%Mg
%Na
%K


Chevrolet, Transport Nagar
1%
6%
34%
59%
%Ca
%Mg
%Na
%K


Roadways Workshoap, Old ISBT
12%
3%
51%
34%
%Ca
%Mg
%Na
%K

CHAPTER – 7

CONCLUSION AND RECOMMENDATIONS

- The wastes water generated by Motor Servicing Center get mixed with domestic wastes and pollute the groundwater.

- The groundwater is only source of drinking in many areas of Doon Valley. Thus, a large Valley population is at risk of consuming polluted water.

- With respect to physico-chemical properties of the samples collected from the Motor Servicing Center of Doon Valley, it is conforming to desirable or permissible limits of BIS or WHO.

- The Oil and Grease content in the samples are conforming to the desirable limit of BIS which is 10 mg/L. **Roadways Workshop,** Old ISBT has the highest Oil and Grease content with **76 mg/L.**

- All the samples from the Motor Servicing Centers has Cation % in the order of **Ca>Mg>Na>K.**

- Ca % contributes almost half of the total Cation analysed.

- The fast automobile growth also results in generation of large quantity of wastes. The number of growth of vehicles is alarming and the uprising of numbers of Motor Servicing Center has become a threat. Many times these wastes also do not get collected, treated and disposed. They also have the same fate as domestic wastes in the city.

- The untreated sewage and sewerage flowing in various open drains from the Motor Servicing Center are one of the causes of ground water quality deterioration. Proper sewerage system must be laid in all Motor Servicing Center and the untreated sewage should not be allowed to flow in open drains.

- A regular monitoring of discharged water quality should be done in the Motor Servicing Center. Proper collection and treatment of wastewater and proper collection and disposal of discharge water should be done. No stagnation of wastewater should be allowed to avoid percolation of contaminants in groundwater.

- Disposal of discharged water from the Servicing Center should be prohibited in the city limit to avoid any leaching process in to the groundwater or to provide sewerage system if it is within the city limit.

- It is suggested that some low cost and easy to implement techniques may be provided to the Service Centers to avoid groundwater contamination.

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ANNEXURE – 1

Primary Water Quality Standards

Primary Water Quality Standards

S. No.	Designated Best Use	Class of Water	Criteria
1	Drinking Water source (with conventional treatment)	A	• Total Coliform MPN/100 ml shall be 50 or less • pH between 6.5 to 8.5 • Dissolved Oxygen 6 mg / 1 or more • Biochemical Oxygen demand (BOD) 5 days 200C 2 mg/1 or less
2	Outdoor bathing (organised)	B	• Total Coliform MPN/100 ml shall be 500 or less • pH between 6.5 to 8.5 • Dissolved Oxygen 5 mg / 1 or more • Biochemical Oxygen demand (BOD) 5 days 200C 3 mg/1 or less
3	Drinking Water source (without conventional treatment)	C	• Total Coliform MPN/100 ml shall be 5000 or less • pH between 6 to 9 • Dissolved Oxygen 4 mg / 1 or more • Biochemical Oxygen demand (BOD) 5 days 200C 3 mg/1 or less
4	Propagation of Wildlife	D	• pH between 6.5 to 8.5 for fisheries • Dissolved Oxygen 4 mg / 1 or more • Free Ammonia (as N) 1.2 mg/1 or less
5	Irrigation, Industrial Cooling, Controlled Waste	E	• pH between 6.0 to 8.5 • Electrical Conductivity at 250C µmhos/cm Max. 2250 • Sodium absorption rations Max. 26 • Boron, Max.2 mg/1

Ref: CPCB (1999). Bio mapping of rivers, Parivesh New Letter, 5 (iv), Central Pollution Control Board, Delhi, PP.20.

ANNEXURE – 2

Indian Standard Drinking Water Specifications: IS 10500: 1991

Indian Standard Drinking Water Specifications: IS 10500: 1991

S. No.	Substance / Characteristics	Requirement (desirable limit)	Undesirable effect outside the desirable limit	Permissible limit in the absence of alternate source	Methods of Test (ref. To IS)	Remarks
			Essential Characteristics			
1	Colour, Hazen Units, Max.	5	Above 5, consumer acceptance decreases	25	3025 (part4) 1983	Extended to 25 only if toxic substances, in absence of alternate sources.
2	Odour	Unobjectionable	-	-	3025 (parts 5): 1984	A test cold and when heated. Test at several dilution
3	Taste	Agreeable	-	-	3025 (part 8): 1984	Test to be conducted only after safety has been established
4	Turbidity NTU, Max.	5	Above 5, consumer acceptance decreases	10	3025 (part 7): 1984	
5	PH value	6.5 to 8.5	Beyond this range the water will not effect the mucous membrane and /or water supply system	No relaxation	3025 (part 11): 1984	
6	Total hardness (as CaCo3) mg/1, Max.	300	Encrustation in water supply structures an adverse effect on domestic use	600	3025 (part 21): 1983	
7	Iron (as Fe) mg /l Max.	0.3	Beyond this limit taste/appearance are affected has adverse effect on domestic uses and water supply structures and promotes iron bacteria	1	3025 (part 21): 1983	
8	Chlorides (as Cl) mg/1 Max.	250	Beyond this limit, taste corrosion and palatability are affected	1000	3025 (part 32): 1988	
9	Residual, free chloride, mg/1 Min.	0.2			3025 (part 26): 1986	To be applicable only when water is chlorinated. Tested at consumer end. When protection against viral infection is required, it should be Min. 0.5 mg/1
			Desirable characteristics			
1	Dissolved solids mg/1 Max.	500	Beyond the palatability decreases and may cause gastro intestinal irritation	2000	3025 (part 16): 1986	
2	Calcium (as Ca) mg/1 Max.	75	Encrustation in water supply structure and adverse effects on domestic use	200	3025 (Part 16) 1986	
3	Magnesium (as Mg) mg/1, Max.	30	Encrustation in water supply structure and adverse effects on domestic use	1.5	16,33,34 of IS 3025: 1964	
4	Copper (as Cu) mg/1 Max.	0.05	Beyond taste, discoloration of pipes, fitting and utensils will	0.3	35 of 3025: 1964	

S. No.	Substance / Characteristics	Requirement (desirable limit)	Undesirable effect outside the desirable limit	Permissible limit in the absence of alternate source	Methods of Test (ref. To IS)	Remarks
			be caused beyond this			
5	Manganese (as Mn) mg/1, Max.		Beyond this limit taste/appearance are affected, has adverse effect on domestic uses and water supply structures.	0.3	35 of 3025: 1964	
6	Sulphate (as 200 So2), mg/1, Max.	200	Beyond this causes gastro intestinal irritation when magnesium or sodium are present	400	3025(part 24): 1986	May be extended up to 400 provided (as Mg) does not exceed 30
7	Nitrate (as No2) mg/l, Max.	45	Beyond this methaemoglobinemia take place	100	3025 (part24): 1988	To be tested when pollution is suspected
8	Fluoride (as F) mg/1, Max.	1	Fluoride may be kept as low as possible. High fluoride may cause fluorosis	1.5	23 of 3025:1964	To be tested when pollution is suspected
9	Phenolic compounds (as C6H5OH) mg/1, Max.	0.001	Beyond this it may cause objectionable taste and odour	0.002	54 of 3025:1964	To be tested when pollution is suspected
10	Mercury (as Hg) mg/1, Max.	0.001	Beyond this the water becomes toxic	No relaxation	(See not mercury ion analyses)	To be tested when pollution is suspected
11	Cadmium (as cd), mg/1, Max.	0.01	Beyond this the water becomes toxic	No relaxation	(See note)	To be tested when pollution is suspected
12	Selenium, (as Se). mg/1, Max.	0.01	Beyond this the water becomes toxic	No relaxation	28 of 3025:1964	To be tested when pollution is suspected
13	Arsenic (As) mg/1, Max.	0.05	Beyond this the water becomes toxic	No relaxation	3025 (part 37); 1988	To be tested when pollution is suspected
14	Cyanide (as CN) mg/1, Max.	0.05	Beyond this the water becomes toxic	No relaxation	3025 (part 27) 1988	To be tested when pollution is suspected
15	Lead (as Pb), mg/1, Max.	0.05	Beyond this the water becomes toxic	No relaxation	(See note)	To be tested when pollution is suspected
16	Zinc (as Zn) mg/1, Max.	5	Beyond this limit it can cause astringent taste and an opalescence taste and an opalescence in water	15	39 of 3025:1964	To be tested when pollution is suspected
17	Anionic detergents (as MBAS) mg/1, Max.	0.2	Beyond this it can cause a light froth in water	1	Methylene-blue extraction method	To be tested when pollution is suspected
18	Chromium (as Cr6+) mg/1, Max.	0.05	May be carcinogenic above this limit	No relaxation	38 of 3025:1964	To be tested when pollution is suspected
19	Poly nuclear aromatic hydra carbons (as PAH) mg/1, Max.	-	May be carcinogenic above this limit		-	-
20	Mineral oil mg/1,	0.01	Beyond this limit undesirable	0.03	Gas	-

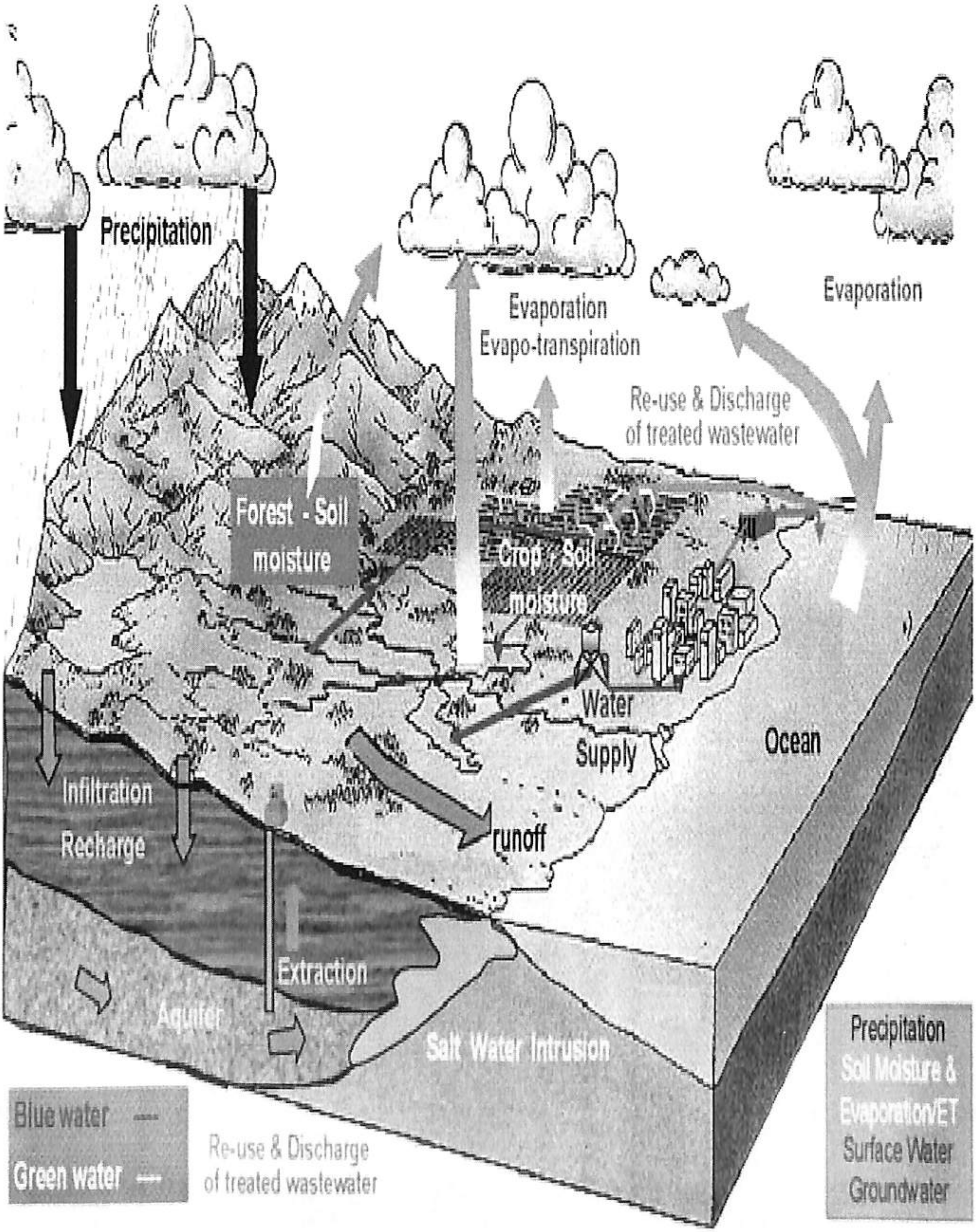
S. No.	Substance / Characteristics	Requirement (desirable limit)	Undesirable effect outside the desirable limit	Permissible limit in the absence of alternate source	Methods of Test (ref. To IS)	Remarks
	Max.		taste and odour after chlorination take place.		Chromatography method	
21	Pesticides mg/1, Max.	Absent	Toxic	0.001	-	-
22	Radioactive material	-	-	-	58 of 3025:1964	-
23	Alpha emitters bq/1, Max.	-	-	0.1	-	-
24	Beta emitter pci/1, Max.	-	-	1	-	-
25	Aluminium (as Al) mg/1, Max.	200	Beyond this limit taste becomes unpleasant	600	13 of 3025:1964	-
26	Aluminium (as Al) mg/1, Max.	0.03	Cumulate effect is reported to cause dementia	0.2	31 of 3025:1964	-
27	Boron mg/1, Max.	1	-	5	29 of 3029:1964	-

Source: Indian Standard Drinking Water Specification – IS 10500, 1994

ANNEXURE – 3

WATER CYCLE : Picture reproduced from UN-World Water Development Report 2006-Water a shared responsibility

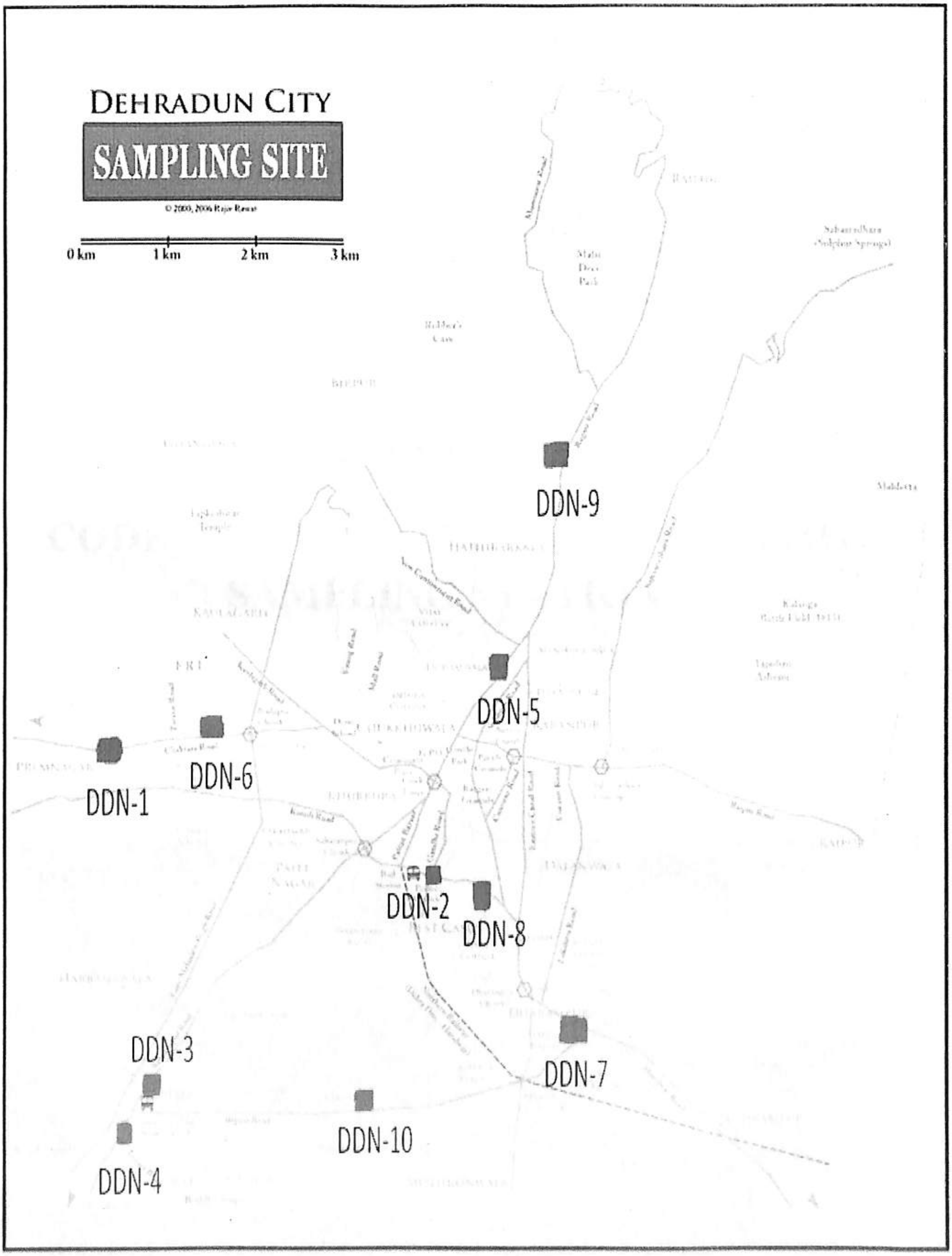
WATER CYCLE : Picture reproduced from UN-World Water Development Report 2006-Water a shared responsibility.



ANNEXURE – 4

MAP OF SAMPLING SITE

Map of Sampling Site



ANNEXURE – 5

CODE, NAME AND LOCATION OF THE SAMPLING STATION

Code, name and location of the Sampling Locations

SL. No	CODE	NAME OF THE SERVICING CENTER	LOCATION
1.	DDN-1	Bajaj Servicing Center	Premnagar
2.	DDN-2	Hyundai Service Center	Prince Chowk
3.	DDN-3	Oberoi Motors Workshop	Majra
4.	DDN-4	Chevrolet Workshop	Transport Nagar
5.	DDN-5	Mohit Auto Service Center	Rajpur Road
6.	DDN-6	Rohan Motors	Chakrata Road
7.	DDN-7	Hyundai Workshop	Haridwar Road
8.	DDN-8	Roadways Workshop	Old ISBT
9.	DDN-9	Mayur Auto	Rajpur Road
10.	DDN-10	Mahindra and Mahindra	Kargi Chowk