EFFECT OF FACTORY WASTE ON SOIL AND GROUND WATER QUALITY FROM LOTE M.I.D.C.

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A thesis submitted to

DR. BALASAHEB SAWANT KONKAN KRISHI VIDAYPEETH, DAPOLI

(Agricultural University)

Dist. Ratnagiri (Maharashtra State), India

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

(AGRICULTURE)

in

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CERTIFICATE

This is to certify that, the thesis entitled **"Effect of factory waste on soil and ground water quality from Lote M.I.D.C"** submitted to the Faculty of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra State, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY,** embodies the results of a piece of *bonafide* research carried out by **Mr. MANOJ KUMAR DEV** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma or published in other form. All the assistance and help received during the course of investigation and the sources of literature have been duly acknowledged by him.

Place: Dapoli **(S. S. Prabhudesai)**
Date: July, 2015 Chairman,
Advisory Committee
and
Research Guide

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DIST.RATNAGIRI, MAHARASHTRA

Title of Thesis	:	**"Effect of Factory Waste on Soil and Ground Water Quality from Lote M.I.D.C. "**
Name of the student	:	Manoj Kumar Dev
Year	:	2013-2015
Regd. No.	:	2301
Name and Designation of Research Guide	:	**Dr. S.S. Prabhudesai** Professor and Head Department of Soil Science and Agricultural Chemistry, Dr. B.S.Konkan Krishi Vidyapeeth, Dapoli

ABSTRACT

For the present investigation entitled,"Effect of factory wastes on soil and ground water quality from Lote M.I.D.C.",soil samples from mango and coconut orchard near M.I.D.C. Lotearea from Awashi(Dist. Ratnagiri) in the pre and post-monsoon season were collected.Water samples were taken from wellssituated around the industrial area during April, 2014 to March, 2015 at one month interval throughout the year.

Thephysico-chemical properties, micronutrient and heavy metal concentrations of soil were determined during pre and post-monsoon season. The physico-chemical properties viz., pH, electrical conductivity, organic carbon, available sulphur and micronutrient viz. zinc, copper and manganese increased after the monsoon in soil. The available nitrogen, phosphorus, potassium, exchangeable calcium and magnesium were higher concentration during pre-monsoon season. During pre-monsoon heavy metal viz.,cobalt and chromium had higher concentration as compared to post-monsoon season and nickel

and lead increased in post-monsoon season in soilbelow the maximum permissible limit (ISI, 1996).

Different parameter viz., pH, EC, bicarbonate, calcium, magnesium, sodium, and chlorideswere estimated from ground water.The Sodium Adsorption Ratio was calculated.Most of the water samples were below the toxic limit for pH, bicarbonate, calcium, magnesium, chloride concentration in ground water throughout the year. The carbonate concentration was not observed in any of the water samples throughout the year. All water samples come under the excellent and good water class for electrical conductivity. The Sodium Adsorption Ratio also found less than 10 in all well water samples, hence water has low sodium hazard and safe for irrigation purpose.

The heavy metalviz., iron, zinc, cobalt concentration present in ground water were below the tolerance limit for drinking and irrigation purpose throughout the year.

The study indicated that there is no much adverse effect of waste water on adjacent soil and ground water. However there is increase in the concentration of heavy metal like nickel, hence the long term monitoring of industrial waste water need to be done.

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"If you accept the expectations of others, especially negative ones,
Then you never will change the outcome."

"Coming together is beginning, carrying together is progress and keeping together is success", this phrase comes to be true, while completing the post graduation.

Success is not possible lonely and any creativity is possible only after the involvement of many minds and hands to beautiful it. Emotions cannot be expressed adequately in words it is nearly the formalities. Traditional formal words of acknowledgment will not project the picture of volcano of feeling while expressing a deep sense of gratitude to my known and unknown hands which pushed and put me on right path and enlightened me with their experience, knowledge and wisdom and shall ever remain grateful to them.

*First of all, I fervently pray my obeisance to the "**Shri Hanumanji**" who gave me the wisdom and ability to be who I'm today and made me able to do this task.*

*"The culmination of research work is a corner stone in the life of any student with research guide being the driving force behind." At this time, I am on that golden moment of my life I feel privileged to express my deep affection, respect and gratitude to my Research Guide and Chairman of my Advisory Committee **Dr. S. S. Prabhudesai**, Professor and Head, Dept. of Soil Science and Agricultural Chemistry, Dr. B.S.K.K.V., Dapoli, for his scholastic guidance, versatile advice, constant encouragement, mental support, patience, unfailing co-operation, hard work, kind but constructive criticism and inspiring discussion throughout the course of my post graduate study gave me this unique experience of planning, conducting and presenting the research work.*

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Place: Dapoli
Date: July, 2015 *(Manoj Kumar Dev)*

APPENDIX

ABBREVIATIONS USED

%	:	Per cent
/	:	Per
@	:	at the rate
<	:	Less than
>	:	Greater than
^{0}C	:	Degree Celsius
AAS	:	Atomic Absorption Spectrophotometer
$AgNO_3$	:	Silver nitrate
ALPHA	:	American Public Health Association
$BaCl_2$	:	Barium Chloride
BDL	:	Below Detection Limit
BIS	:	Bureau of Indian Standard
CEC	:	Cation exchange capacity
CGWB	:	Central Ground Water Board
CH3COOH	:	Acetic acid
Cm	:	Centimeter (s)
CPCB	:	Central Pollution Control Board
DTPA	:	Di-ethylene Tri-amine Penta-acetic Acid
EBT	:	Eriochrome black -T
EC	:	Electrical Conductivity
EDTA	:	Ethylene Di-amine Tetra Acetic Acid
EPA	:	Environmental Protection Agency
et al.	:	and other
g	:	Gram
g kg^{-1}	:	Gram per kilogram
H_2SO_4	:	Sulphuric Acid
ha	:	hectare
i.e.	:	That is

ISI	:	Indian Standard Institute
$K_2Cr_2O_7$	:	Potassium dicromate
KCl	:	Potassium chloride
kg	:	Kilogram
kg ha^{-1}	:	Kilogram per hectare
$KMnO_4$	:	Potassium permanganate
M.S.	:	Maharashtra State
M.T.	:	Metric tones
MIDC	:	Maharashtra Industrial Development Corporation
meq g^{-1}	:	Mili-equivalent per gram
meq L^{-1}	:	Mili-equivalent per liter
mg	:	Milligram
mg kg^{-1}	:	Mili-equivalent per kilogram
mg L^{-1}	:	Mili-equivalent per liter
ml	:	Milliliter
mm	:	Millimeter
ppm	:	Parts per million
$NaHCO_3$	:	Sodium bicarbonate
NH_4-N	:	Ammonium nitrogen
NH_4OAc	:	Neutral-normal-ammonium acetate
No.	:	Number
SSAC	:	Soil Science and Agricultural Chemistry
SAR	:	Sodium Adsorption Ratio
RSC	:	Residual Sodium Carbonate
viz.	:	Namely
wt.	:	Weight
X^2	:	Chi-square test

CHAPTER I

INTRODUCTION

Maharashtra is one of the most industrialized statein India. Many industries are situated all over the state.The industries play animportant role forthe development of Indian economyand employment generation. However, the industrial development sometimecreatesadverse effect on the human population, water, air, soil and environment.

Konkan region of Maharashtra state with its rich natural resource also has a remarkable contribution in the field of industrialization. In Ratnagiri district of Konkan region many industries are situated at Lote M.I.D.C. viz.,Gharda Chemicals Ltd, Kansai Nerolac Paints, Bhavna Petrochem Pvt. Ltd, PentokeyOrgany Ltd, Ratnagiri Chemical Pvt. Ltd, S.R. Drugs, National Organic Chemical Industries Ltd, Shireen Industries, Indian Oxalate Ltd, Parso Pharmaceutical &Chemicals, Sandvik, Amico Pesticides Ltd, Hindustan Unilever Ltd, Eltech Fine ChemPvt.Ltd, Filtra Catalysts & Chemicals Ltd etc.These industries produce lots of chemical waste in solid and liquid forms, which are disposed of in the adjacent land.The liquid wastes are disposed through CETP (Common Effluents

Treatment Plants)or flowed by small canal and finally in river. These chemicalwastes contain heavy metals andmany harmful substances,which affect the physical, chemical and biological properties of soils and contaminate surface water (Patel *et al.* 2015). These pollutants may percolate into the ground water, which may ultimately cause health hazards among the human beings and livestock,on consumption. The Contaminated ground waterdeterioratesthe quality of drinking water and also makes it unsuitable for irrigation.

Soil is one of the vital resources on the planet Earth. Soil is an important system of terrestrial ecosystem, and direct discharge of industrial effluents especially those without any treatment may influence thephysico-chemical and biological properties of soil,related to soil fertility (Kumar*et al.*2012). In the recent years, considerable attention has been paid to disposal of industrial waste, which is usually discharged on land or into the water sources. Inherent soil physico-chemical properties influence the behavior of soil and hence, knowledge of soil property is important (Kumar *et al.* 2012).

Water is an important life supporting material and required for all biotic communities. Water isa factor of production in virtually all enterprises, including agriculture, industry and the service sector.The society depends on water for domestic needs, irrigation, sanitation, and disposal of waste.Normally water is never pure inthe chemical sense (Agale*et al.* 2013). In water impurities are in very low amounts, but due to rapid industrialization, over population, indiscriminate use of chemicals causing water pollution and exploitation of ground water disturbs the state of equilibrium of aquifer (Ramesh *et al.*, 2014). The effluents or waste from industries, sometimes percolate through subsoil and reached the ground water table forming contaminated pool, which disturb the natural ground water quality by changing its chemical composition (Pondhe*et. al.*,1992).Contaminated water when used for irrigation purpose affects the soilquality and crop health.

Thephysico-chemical analysis of soil and ground waterreveal the impact of industrial waste on soil health and pollution of ground water.

In view of this, the present study entitled "Effect of factory waste on soil and ground water quality from Lote M.I.D.C." was undertaken with the following objectives:

1) To study the effect of industrial waste on physico-chemical properties of soil.
2) To study the effect of industrial waste on ground water quality.
3) To study the concentration of heavy metals in soil and ground water.

CHAPTER II
REVIEW OF LITERATURE

The contamination of soil and water with industrial effluent alters their properties. The soil pollution may result in accumulation of toxic substances in soil and reduce the soil fertility, whereas water contamination may make it unsuitable for drinking as well as for irrigation. The analysis of soil and ground water from Industrial area is important for the maintenance of soil health and water quality, because soil is most important to agriculture point of view and water is most essential for life. Therefore, the present investigation was carried out to study the, "Effect of factory waste on soil and ground water quality from Lote M.I.D.C."

The available literature on the aspects have been reviewed and presented below under various heads:

2.1Effect of Industrial waste on physico-chemical properties of soil.

2.2 Effect of Industrial waste on ground water quality.

2.3 Effect of heavy metals in waste water on soil and ground water quality.

2.1 Effect of Industrial waste on physico-chemical properties of soil.

2.1.1 pH

Saha (2005) studied the effects of contaminated wateron soil near the industrial area Ratlam and Nagda of Madhya Pradesh.He observed the pH of unpolluted soil has mean value 7.86 in both pre and post monsoon seasonswhile the pH of polluted soil has mean value 8.37 and 7.94 in pre and post monsoon season, respectively in Ratlam. In Nagda,the pH of unpolluted soil was 8.29 and 8.18 in pre and post monsoon season, respectively and the pH of polluted soil was 7.90 and 8.11 in pre and post monsoon season, respectively.

Joshi*et al.* (2007) studied the effect of sugar factoryeffluent on physic-chemical properties of soil from Wardha district of Maharashtra and observed that the pH of waste water irrigated surface soil was 6.4, 7.0 and 6.8 with a mean value of 6.7 in summer, rainy and winter season, respectively. The pH of well water irrigated surface soil was 8.0, 7.9 and 7.7 with a mean value of 7.9 in summer, rainy and winter season, respectively.

Ravinder *et al.*(2007) studied the impact of tannery industries on ground water and soil quality at Warangal district and observed that the pH of surface soil was 6.5.

Roy *et al.* (2008) studied the effect of paper industry waste water on soil properties of Nagpur district, Maharashtra and observed that the pH of waste water irrigated surface soil were 8.22, 8.45 and 8.20 with mean value of 8.29 in summer, rainy and winter season, respectively. The pH of well water irrigated surface soil was 7.52, 7.38 and 6.80 with mean value of 7.23 in summer, rainy and winter season, respectively.

Lawande *et al.* (2010) studied the impact of industrial waste on soil around Kurkumbh Industrial area Daund, Pune district (MS) and observed that the soil pH ranged from 4.64 to 8.46.

Ahmad *et al.* (2012) studied the influence of Dye industrial effluent on physic-chemical properties of soil at Bharaivgarh, Ujjain district, Madhya Pradesh and observed that the pH of uncontaminated soil varied from 6.90 to 7.31 while the pH of effluents irrigated soil varied from 7.76 to 8.7.

Kumar and Srikantaswamy (2012) studied the physico-chemical characteristic of industrial zone soil of Mysore ofKarnataka, India and observed that the pH of the soil ranged from 6.86 to 7.40 and 6.6 to 7.4 in pre and post-monsoon season, respectively.

Ladwani*et al.*(2012) studied the effects of Iron and steel industry effluents situated at Bhandara, Maharashtra and reported the pH of soil ranged from 7.4 to 11.5.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and observed that themean value of soil pH was 7.30, 7.56 and 7.32 in summer, monsoon and winter season, respectively.

Shaikh *et al.*(2013) studied the physico-chemical properties of the soil near the Siddheshwar Dam Hindoli district, Maharashtra and that found onaverage pH value 5.44.

2.1.2 Electrical conductivity

Saha(2005) studied the effects ofcontaminated water on soil near the industrial areas Ratlam and Nagda of Madhya Pradesh.He observed the EC of unpolluted soilto be 0.42 and 0.36 dSm^{-1} in pre and post monsoon season, respectively while the EC of polluted soilwas 0.84 and 0.64 dSm^{-1} in pre and post monsoon season, respectively of industrial area Ratlam. In the industrial area Nagda,the EC of unpolluted soil was 0.71 and 0.23 dSm^{-1}in pre and post monsoon season, respectively while the EC of polluted soilwas 4.44 and 0.52 dSm^{-1}in pre and post monsoon season, respectively.

Roy*et al.* (2007) studied the effect of sugar factory effluent on some physico-chemical properties of soil from Wardha district of Maharashtra and observed that the electrical conductivity of waste water irrigated surface soil were 0.034, 0.032 and 0.28 dSm^{-1} with mean value of 0.31 in summer, rainy and winter season, respectively. The electrical conductivity of well water irrigated surface soil were 0.22, 0.25 and 0.26 dSm^{-1} with mean value of 0.24 dSm^{-1} in summer, rainy and winter season, respectively.

Roy *et al.* (2008) studied the effect of paper industry waste water on soil properties of Nagpur district of Maharashtra and observed that the electrical conductivity of waste water irrigated surface soil were 6.04, 1.84 and 1.10 dSm^{-1} with mean value of 2.99 dSm^{-1} in summer, rainy and winter season, respectively. The electrical conductivity of well water irrigated surface soil were 0.26, 0.22 and 0.21 dSm^{-1} with mean value of 0.23 dSm^{-1} in summer, rainy and winter season, respectively.

Shanthi *et al.* (2011) studied the sugar factory waste affected soil of Cuddalore district of Tamil Nadu and observed that the soil EC ranged from 0.06 to 0.20 dSm^{-1}.

Kumar and Srikantaswamy (2012) studied the physico-chemical characteristic of industrial zone soil of Mysore of Karnataka, India and observed that the electrical conductivity of soil ranged from 79.00 to 88.00 $\mu Scm^{-1}$and 76.00 to 85.00μScm^{-1}in pre and post-monsoon season, respectively.

Ladwani*et al.* (2012) studied the impact of industrial effluent on agricultural soil around Iron and steel industry at Bhandara district, Maharashtra and observed that the soil EC ranged from 0.540 to 0.522 dSm^{-1}.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and observed that the electrical conductivity of soil as mean value were 27.67, 26.50 and 24.18 $mhocm^{-1}$ in summer, monsoon and winter seasons, respectively.

2.1.3 Organic carbon

Tripathi (2006) studied the impacts of polluted underground water from Seepage of textile industrial effluents on soil properties in Jodhpur, Rajasthan and found that the organic carbon in normal soil and contaminated soil were 4.5 gkg^{-1} and 2.7 gkg^{-1}, respectively.

Joshi*et al.* (2007) studied the effect of sugar factory effluent on physico-chemical properties of soil fromWardha district ofMaharashtra and observed that the organic carbon of waste water irrigated surface soil was 6.9, 4.8 and 5.0g kg^{-1} with a mean value of 5.6 g kg^{-1} in summer, rainy and winter season, respectively. The organic carbon of well water irrigated surface soil was2.0, 1.8 and 2.2 g $kg^{-1}$with a mean value of 2.0 g kg^{-1} in summer, rainy and winter season, respectively.

Roy *et al.* (2008) studied the effect of paper industry waste water on soil properties of Nagpur district of Maharashtra and observed that the organic carbon of waste water irrigated surface soil was 2.20, 2.58 and 2.72 per cent with a mean value of 2.50 per cent in summer, rainy and winter season, respectively. The organic carbon of well water irrigated surface soil was 0.22, 0.27 and 0.50 per cent with a mean value of 0.33 per cent in summer, rainy and winter season, respectively.

Ahmad *et al.* (2012) studied the influence of Dye industrial effluent on physico-chemical properties of soil at Bhairavgarh, Ujjain district, Madhya Pradesh and found that the soil organic carbon varied from 0.32 to 0.42 per cent and 0.18 to 0.24 per cent in contaminated and uncontaminated soil, respectively.

Ladwani*et al.*(2012) studied the impact of industrial effluent on agricultural soil around Iron and Steel industry at Bhandara of Maharashtra and observed that the soil organic carbon varied from 0.65 to 2.20 Percent.

Balkhande *et al.*(2013) studied the influence of Hingoli and Nanded district sugarcane industry effluents on physiochemical properties of soil and observed that the soil organic carbon varied from 0.39 to 0.44 percent and 0.34 to 0.38 per cent in polluted and non-polluted soil, respectively.

Shaikh and Bhosle (2013) studied the physico-chemical properties of soil near the Siddheshwar Dam Hingoli district ofMaharashtra and found that an average value of organic carbon was 0.09 percent.

2.1.4 Available nitrogen

Joshi*et al.*(2007) studied the effect of sugar factory effluent on physic-chemical properties of soil from Wardha district of Maharashtra and observed that the available nitrogen of waste water irrigated surface soil was 213.25, 276.12 and 126.82 kgha^{-1} with a mean value of 205.4 kgha^{-1}in summer, rainy and winter season, respectively. The available nitrogenof well water irrigated surface soil was 87.81, 126.12 and 123.26 kgha^{-1}with a mean value of 112.4 kgha^{-1} in summer, rainy and winter season, respectively.

Roy *et al.* (2008) studied the effect of paper industry waste water on soil properties of Nagpur district of Maharashtra and observed that the available nitrogen of waste water irrigated surface soil was238, 326 and 176 kgha^{-1}with a mean value of 247 kgha^{-1}in summer, rainy and winter season, respectively. The available nitrogen of well water irrigated surface soil was250, 263 and 75 $kgha^{-1}$with a mean value of 196 $kgha^{-1}$ in summer, rainy and winter season, respectively.

Shanthi *et al.*(2011) studied the sugar factory waste affected soil nearby Cuddalore district of Tamil Nadu and observed that the soil contains very low available nitrogen which varied from 49 to 77 $kgha^{-1}$.

Thambhavani and Sabitha (2011) studied the impact of sugar industry effluent on soil in Tamil Nadu and observed that the available nitrogen of surface and sub-surface soil varied from 82 to 98 kg/acre and 70 to 88 kg/acre, respectively.

Ladwani*et al.(*2012) studied the impact of industrial effluent on agricultural soil around Iron and Steel industry at Bhandara of Maharashtra and observed that the soil available nitrogen in the ranged of 121.67 to 218.26 $kgha^{-1}$.

2.1.5 Available phosphorus

Tripathi (2006) studied the impacts of polluted underground water from seepage of textile industrial effluents on soil properties in Jodhpur of Rajasthan and observed that the concentration of available phosphorus in normal soil and contaminated soil were 7.3 $mgkg^{-1}$ and 16.0 $mgkg^{-1}$, respectively.

Joshi*et al.*(2007) studied the effect of sugar factory effluent onphysico-chemical properties of soil from Wardha district of Maharashtra and observed that the available phosphorus of waste water irrigated surface soil was16.91, 15.62 and 27.22 $kgha^{-1}$ with a mean value of 19.22 $kgha^{-1}$in summer, rainy and winter season, respectively. The available phosphorusof well water irrigated surface soil was6.51, 10.16 and 12.28 $kgha^{-1}$with a mean value of 9.65 $kgha^{-1}$ in summer, rainy and winter season, respectively.

Roy *et al.* (2008) studied the effect of paper industry waste water on soil properties of Nagpur district of Maharashtra and observed that the available phosphorus of waste water irrigated surface soil was1.44, 1.68 and 1.44 kgha^{-1}with a mean value of 1.52 kgha^{-1}in summer, rainy and winter season, respectively. The available phosphorus of well water irrigated surface soil was2.12, 1.59 and 1.64 kgha^{-1}with a mean value of 1.78 kgha^{-1} in summer, rainy and winter season, respectively.

Shanthi *et al.*(2011) studied the sugar factory waste affected soil nearby Cuddalore district of Tamil Nadu and observed the available phosphorus varied from 43 to 49 kgha^{-1}.

Thambhavani and Sabitha (2011) studied the impact of sugar industry effluent on soil in Tamil Nadu and observed that the available phosphorus of surface and sub-surface soil were varied from 5.0 to 20 kg/ac and 4.9 to 10.8 kg/ac, respectively.

Ahmad *et al.* (2012) studied the influence of Dye industrial effluent on physico-chemical properties of soil at Bhairavgarh, Ujjain district of Madhya Pradesh and found that the available phosphorus in polluted and non-polluted soil varied from 0.83 to 0.98 mgkg^{-1} and 0.83 to 0.98 mgkg^{-1}, respectively.

Ladwani*et al.*(2012) studied the impact of industrial effluent on agricultural soil around Iron and Steel industry at Bhandara of Maharashtra and observed that the soil available phosphorus ranged from 0.64 to 5.34 kgha^{-1}.

2.1.6 Available potassium

Saha (2005) studied the effects of contaminated water on soil near the industrial areas Ratlam and Nagda of Madhya Pradesh.He observed that the available potassium of unpolluted soil has mean value 0.10 and 0.07 per cent in pre and post monsoon season, respectively while the available potassium of polluted soil has mean value 0.05 and 0.26 per cent in pre and post monsoon season, respectively of industrial area Ratlam. In the industrial area Nagda,the available potassium of unpolluted soil has mean value 0.07and 0.25 per cent in pre and post monsoon season, respectively while the available potassium of polluted soil has mean value 0.15 and 0.64 per cent in pre and post monsoon season, respectively.

Joshi*et al.* (2007) studied the effect of sugar factory effluent on physic-chemical properties of soil from Wardha district of Maharashtra and observed that the available potassium of waste water irrigated surface soil was 418, 680 and 890 kgha^{-1} with a mean value of 662.7 kgha^{-1} in summer, rainy and winter season, respectively. The available potassiumof well water irrigated surface soil was 285, 388 and 660 kgha^{-1}with a mean value of 444 kgha^{-1} in summer, rainy and winter season, respectively.

Roy *et al.* (2008) studied the effect of paper industry waste water on soil properties of Nagpur district of Maharashtra and observed that the available potassium of waste water irrigated surface soil was1070, 748 and 558 kgha^{-1}with a mean value of 792 kgha^{-1}in summer, rainy and winter season, respectively. The available potassium of well water irrigated surface soil was686, 420 and 628 kgha^{-1}with a mean value of 578 kgha^{-1} in summer, rainy and winter season, respectively.

Kumar and Srikantaswamy (2012) studied the physico-chemical characteristic of industrial zone soil of Mysore city of Karnataka, India and observed that the available potassium in soil varied from 6.1 to 17.0 ppm and 3.5 to 13.7 ppm in pre and post-monsoon season, respectively.

Ladwani*et al.*(2012) studied the impact of industrial effluent on agricultural soil around Iron and Steel industry at Bhandara, Maharashtra and observed that the soil available potassium in the ranged from 60 to 70.28 kgha^{-1}.

Ahmad *et al.* (2012) studied the influence of Dye industrial effluent on physico-chemical properties of soil at Bhairavgarh, Ujjain district of Madhya Pradesh and found that the available potassium in contaminated and uncontaminated soil varied from 50.7 to 58.7 ppm and 30.7 to 33.8 ppm, respectively.

Balkhande *et al.* (2013) studied the influence of Hingoli and Nanded district sugarcane industry effluents on physiochemical properties of soil and observed that the soil potassium in polluted and non-polluted soil varied from 0.07 to 0.11 per cent and 0.04 to 0.05 per cent, respectively.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and found the mean value of available potassium in soil were 35.00, 31.00 and 34.40 $\mu g\ g^{-1}$ in summer, monsoon and winter season, respectively.

2.1.7Exchangeable calcium

Saha (2005) studied the effects of contaminated water on soil near the industrial areas Ratlam and Nagda of Madhya Pradesh. Heobserved that the concentration of exchangeable Calcium of unpolluted soil has a mean value 0.59 and 0.57 per cent in pre and post monsoon season, respectively while the concentration of Calcium of polluted soil has mean value 1.10 and 1.18 per cent in pre and post monsoon season, respectively on industrial area Ratlam. In the industrial area Nagda,the exchangeable Calcium of unpolluted soil has mean value 0.33 and 0.98 per cent in pre and post monsoon season, respectively while the exchangeable Calcium of polluted soil has mean value 2.56 and 2.33 per cent in pre and post monsoon season, respectively.

Joshi*et al.* (2007) studied the effect of sugar factory effluent on physic-chemical properties of soil from Wardha district of Maharashtra and observed that the exchangeable calcium of waste water irrigated surface soil was 280, 265 and 370 kgha^{-1} with a mean value of 285 kgha^{-1} in summer, rainy and winter season, respectively. The exchangeable calciumof well water irrigated surface soil was380, 365 and 355 kgha^{-1}with a mean value of 366kg ha^{-1} in summer, rainy and winter season, respectively.

Roy *et al.*(2008) studied the effect of paper industry waste water on soil properties of Nagpur district of Maharashtra and observed that the exchangeable calcium of waste water irrigated surface soil was320, 305 and 310 kgha^{-1}with a mean value of 312 kgha^{-1}in summer, rainy and winter season, respectively. The exchangeable calcium of well water irrigated surface soil was340, 300 and 320 kgha^{-1}with a mean value of 578 kgha^{-1} in summer, rainy and winter season, respectively.

Lawande *et al.*(2010) studied the effect of industrial waste water on soil around Kurkumbh industrial area Daund, Pune district (MS) and observed that the soil exchangeable calcium varied from 8.0 to 440.8 mgKg^{-1}.

Ladwani *et al.*(2012) studied the impact of industrial effluent on agricultural soil around Iron and Steel industry at Bhandara, Maharashtra and found the wide ranged of the exchangeable calcium from 9.0 to 76.15 meq 100^{1}g in soil.

Ahmad *et al.*(2012) studied the influence of Dye industrial effluent on physico-chemical properties of soil at Bharavgarh, Ujjain district of Madhya Pradesh and observed that the exchangeable calcium varied from 189 to 273mg kg^{-1}and 63 to 94.5 mg kg^{-1} in contaminated and uncontaminated soil, respectively.

Kumar and Srikantaswamy (2012) studied the physico-chemical characteristic of industrial zone soil of Mysore city of Karnataka, India and observed the exchangeable calcium in soil varied from 110 to 262 mg kg^{-1} and 94 to 188 mg kg^{-1} in pre and post-monsoon season, respectively.

Rajbala and Bhaskar(2012) studied the impact of steel industry waste on soil nearby Jindal Strips Ltd of Hissar city, Haryana and observed that the calcium found a wide ranged from 2.4 to 81.6 mgL^{-1}.

Shaikhand Bhosle (2013) studied the physico-chemical properties of soil near the Siddheshwar Dam Hingoli district, Maharashtra and that found the calcium as average value was 112 $mgkg^{-1}$.

2.1.8 Exchangeable magnesium

Saha (2005) studied the effectsof contaminated water on soil near the industrial areas Ratlam and Nagda of Madhya Pradesh. He observed that the concentration of exchangeablemagnesium of unpolluted soil has mean value 0.17 and 0.29 per cent in pre and post monsoon season, respectively while the magnesium of polluted soil has mean value 0.29 and 0.43 per cent in pre and post monsoon season, respectively of industrial area Ratlam. In industrial area Nagda, the concentration of exchangeable magnesium in unpolluted soil has mean value 0.14 and 0.13 per cent in pre and post monsoon season, respectively while the magnesium of polluted soil has mean value 0.49 and 0.20 per cent in pre and post monsoon season, respectively.

Joshi*et al.* (2007) studied the effect of sugar factory effluent on physic-chemical properties of soil from Wardha district of Maharashtra and observed that the exchangeable magnesium of waste water irrigated surface soil was 89, 82 and 67 $kgha^{-1}$ with a mean value of 79 $kgha^{-1}$ in summer, rainy and winter season, respectively. The exchangeable magnesium of well water irrigated surface soil was 74, 57 and 63 $kgha^{-1}$with a mean value of 65 $kgha^{-1}$ in summer, rainy and winter season, respectively.

Roy *et al.* (2008) studied the paper industry waste water on soil properties of Nagpur district Maharashtra and observed that the exchangeable magnesium of waste water irrigated surface soil was105, 86 and 93 $kgha^{-1}$with a mean value of 95 $kgha^{-1}$in summer, rainy and winter season, respectively while the exchangeable magnesium of well water irrigated surface soil was101, 129 and 100 $kgha^{-1}$with a mean value of 110 $kgha^{-1}$ in summer, rainy and winter season, respectively.

Lawande *et al.*(2010) studied the effect of industrial waste water on soil around Kurkumbh industrial area Daund, Pune district (MS) and observed that the exchangeable magnesium in soil varied from 2.40 to 58.48 $mgKg^{-1}$.

Kumar and Srikantaswamy (2012) studied the physico-chemical characteristic of industrial zone soil of Mysore city, Karnataka, India. They observed the exchangeable calcium in soil varied from 56 to 376 mg kg^{-1} and 42 to 240 mg kg^{-1} in pre and post-monsoon season, respectively.

Ladwani *et al.*(2012) studied the impact of industrial effluent on agricultural soil around Iron and Steel industry at Bhandara, Maharashtra and found wide ranged of the exchangeable magnesium 0.29 to 45.24 $meqL^{-1}$ in soil.

Ahmad *et al.*,(2012) studied the influence of Dye industrial effluent on physico-chemical properties of soil at Bharavgarh, Ujjain district, Madhya Pradesh and observed that the exchangeable magnesium varied from 8.50 to 45.9 mg kg^{-1} and 3.08 to 6.99 mg kg^{-1} in contaminated and uncontaminated soil, respectively.

Rajbala and Bhaskar (2012) studied the impact of steel industry waste on soil nearby Jindal Strips Ltd of Hissar city, Haryana and observed that the Magnesium varied from 31.2 to 63.4 mgL^{-1}.

Shaikh and Bhosle (2013) studied the physico-chemical properties of soil near the Siddheshwar Dam Hingoli district of

Maharashtra and found the average value of magnesium was 115 mgkg^{-1}.

2.1.9 Available sulphur

Saha (2005) studied the effectsof contaminated wateron soil near the industrial areas Ratlam and Nagda of Madhya Pradesh. He observed that the available sulphur of unpolluted soil as mean value 0.60 and 0.47 per cent in pre and post monsoon season, respectively while the available sulphur of polluted soil has mean value 0.88 and 0.58 per cent in pre and post monsoon season, respectively of industrial area Ratlam. In industrial area Nagda, available sulphur of unpolluted soil has mean value 0.50 and 0.06 per cent in pre and post monsoon season, respectively while the available sulphur of polluted soil has mean value 20.54 and 2.12 per cent in pre and post monsoon season, respectively.

Tripathi (2006) studied the impacts of polluted underground water from seepage of textile industrial effluents on soil properties in Jodhpur, Rajasthan and observed that the concentration of available sulphur in contaminated soil as mean value 9.9 mg L^{-1}.

Lawande *et al.*(2010) studied the effect of industrial waste water on soil around Kurkumbh industrial area Daund, Pune district (MS) and found the available sulphur varied from 35.0 to 125.0 mgKg^{-1}.

Rajbala and Bhaskar(2012) studied the impact of steel industry waste on soil nearby Jindal Strips Ltd of Hissar city, Haryana and found that the available sulphur in soil varied from 12.3 to 41.4 mg L^{-1}.

2.1.10 Micronutrients

2.1.10.1 DTPA-extractable Iron

Joshi*et al.* (2007) studied the effect of sugar factory effluent on physic-chemical properties of soil from Wardha district of Maharashtra and observed that the iron concentration of waste water irrigated surface soil was 16.01, 13.22 and 14.29 mg kg^{-1} with a mean value of 14.51 mg kg^{-1} in summer, rainy and winter season, respectively whilethe well water irrigated surface soil were 7.02, 9.22 and 6.24 mg $kg^{-1}$with a mean value of 7.49 mg kg^{-1}in summer, rainy and winter season, respectively.

Roy *et al.* (2008) studied the effect of paper industry waste water affected soil in three seasons nearby Nagpur district of Maharashtra and found that concentration ofiron in waste water irrigated surface soil was 38.50, 25.50 and 21.50 $mgkg^{-1}$ with a mean value of 28.50 $mgkg^{-1}$ in summer, rainy and winter season, respectivelywhilethe well water irrigated surface soil were 6.00, 10.50 and 10.50 $mgkg^{-1}$ with a mean value of 9.00 $mgkg^{-1}$ in summer, rainy and winter season, respectively.

Thambavani *et al.* (2011) studied the impact of sugar industry effluent on soil in Tamil Nadu and observed that the concentration of micronutrientiron in surface and sub-surface soil varied from 5.21 to 15.87 ppm and 2.84 to 20.51 ppm, respectively.

Kumar and Srikantaswamy (2012) studied the heavy metal pollution assessed in industrial area of soil of Mysore city, Karnataka, India. They observed the iron concentration in soil ranged from 2.5 to 6.5 mg kg^{-1} with a mean value of 4.67 mg kg^{-1} and 2.3 to 6.7 mg kg^{-1} with a mean value of 4.47mg kg^{-1} in dry and wet season, respectively.

Thambavani *et al.* (2012) studied the heavy metals contamination of soil of Dindugul town, Tamil Nadu and observed that the concentration of ironin industrial site soil varied from 7.01 to 11.54 $mgkg^{-1}$.

Bharti *et al.*(2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and found the concentration of iron as mean value was 76.67 ppm, 26.77 ppm and 28.80 ppm in summer, monsoon and winter season, respectively.

Shaikh *et al.* (2013) studied physico-chemical properties of soil near the Siddheshwar Dam Hingoli district of Maharashtra and found the concentration iron was 60.21 mgkg^{-1}.

2.1.10.2DTPA-extractable Zinc

Joshi*et al.* (2007) studied the effect of sugar factory effluent on physic-chemical properties of soil from Wardha district of Maharashtra and observed that the Zn concentration of waste water irrigated surface soil was 3.48, 1.02 and 1.58 mg kg^{-1} with a mean value of 2.03 mg kg^{-1}in summer, rainy and winter season, respectivelywhile the well water irrigated surface soil were 0.50, 0.53 and 0.72 mg kg^{-1}with a mean value of 0.60 mg kg^{-1} in summer, rainy and winter season, respectively.

Roy *et al.* (2008) studied the effect of paper industry waste water affected soil in three seasons nearby Nagpur district of Maharashtra and found that concentration ofzinc in waste water irrigated surface soil was 76.50, 34.00 and 29.00 mg kg^{-1} with a mean value of 46.50 mg kg^{-1} in summer, rainy and winter season, respectively while the well water irrigated surface soil was 1.00, 0.46 and 0.62 mg kg^{-1} with a mean value of 0.69 mg kg^{-1} in summer, rainy and winter season, respectively.

Kumar and Srikantaswamy (2012) studied the heavy metal pollution assessed in industrial area of soil of Mysore city ofKarnataka, India and observed the zinc concentration in soil ranged from 66.0 to 121.0 mg kg^{-1} with a mean value of 95.71 mg kg^{-1} and 68 to 111.6 mg kg^{-1} with a mean value of 89.01mg kg^{-1} in dry and wet season, respectively.

Thambavani *et al.* (2012) studied the heavy metals contamination of soil of Dindugul town, Tamil Nadu and observed that the concentration of zincin industrial site soil varied from 2.01 to 3.02 mg kg^{-1}.

Bharti *et al.*(2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and found the concentrations of Zn as mean value was 13.17 ppm, 18.53 ppm and 7.68 ppm in summer, monsoon and winter season, respectively.

Shaikh *et al.* (2013) studied physico-chemical properties of soil near the Siddheshwar Dam Hingoli district, Maharashtra and found the micronutrient concentration zincwas 21.75, mg kg^{-1}.

2.1.10.3DTPA-extractable Copper

Joshi*et al.* (2007) studied the effect of sugar factory effluent on physic-chemical properties of soil from Wardha district of Maharashtra and observed that the copper concentration of waste water irrigated surface soil was 6.72, 2.68 and 4.23 mg kg^{-1} with a mean value of 4.54 mg kg^{-1} in summer, rainy and winter season, respectively. The copper concentrationof well water irrigated surface soil was 4.18, 2.48 and 3.23 mg $kg^{-1}$with a mean value of 3.29 mg kg^{-1} in summer, rainy and winter season, respectively.

Roy *et al.* (2008) studied the effect of paper industry waste water affected soil in three seasons nearby Nagpur district, Maharashtra and found that concentration ofcopper in waste water irrigated surface soil was 25.50, 20.50 and 16.20 $mgkg^{-1}$ with a mean value of 20.70 $mgkg^{-1}$ in summer, rainy and winter season, respectively while the well water irrigated surface soil 2.02, 1.40 and 1.56 $mgkg^{-1}$ with a mean value of 1.66 $mgkg^{-1}$ in summer, rainy and winter season, respectively.

Samual *et al.* (2011) studied the sugar mill effluents contaminated soil at Cudalore and observed that the mean concentration of copper was 0.75 ppm.

Kumar and Srikantaswamy (2012) studied the heavy metal pollution assessed in industrial area of soil of Mysore city of Karnataka, India and observed the copper concentration in soil ranged from 16 to 20.3 mg kg^{-1} and 6.8 to 18.3 mg kg^{-1} [1] in dry and wet season, respectively.

Thambavani *et al.* (2012) studied the heavy metals contamination of soil of Dindugul town, Tamil Nadu and observed that the concentration of copperin industrial site soil varied from 8.12 to 9.21 $mgkg^{-1}$.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and found the copper as mean value was 36.30 ppm, 30.20 ppm and 13.40 ppm in summer, monsoon and winter season, respectively.

2.1.10.4 DTPA-extractable Manganese

Joshi*et al.* (2007) studied the effect of sugar factory effluent on physic-chemical properties of soil from Wardha district of Maharashtra and observed that the manganese concentration of waste water irrigated surface soil was 1.92, 0.66 and 1.24 mg kg^{-1} with a mean value of 1.27 mg kg^{-1} in summer, rainy and winter season, respectively. The manganese concentrationof well water irrigated surface soil was 2.90, 1.60 and 1.80 mg $kg^{-1}$with a mean value of 2.10 mg kg^{-1}in summer, rainy and winter season, respectively.

Roy *et al.* (2008) studied the paper industry waste water affected soil in three seasons nearby Nagpur district, Maharashtra and found that concentration of manganese in waste water irrigated surface soil was 2.40, 2.70 and 2.72 $mgkg^{-1}$with a mean value of 2.61 $mgkg^{-1}$ in summer, rainy and winter season, respectively. The manganese in well water irrigated surface soil was 1.18, 0.42 and

0.84 mgkg^{-1} with a mean value of 0.81 mgkg^{-1} in summer, rainy and winter season, respectively.

Thambavani *et al.* (2011) studied the impact of sugar industry effluent on soil in Tamil Nadu and observed that the concentration of manganese in surface and sub-surface soil varied from3.34 to 8.33 and 2.90 to 6.07ppm, respectively**.**

Thambavani *et al.* (2012) studied the heavy metals contamination of soil of Dindugul town, Tamil Nadu and observed that the concentration of manganesein industrial site soil varied from 6.12 to 14.72 mgkg^{-1}.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and found the concentration of manganese as mean value was 13.57 ppm, 10.23 ppm and 5.90 ppm in summer, monsoon and winter season, respectively.

Shaikh *et al.*(2013) studied physico-chemical properties of soil near the Siddheshwar Dam Hingoli district, Maharashtra and found the concentration of manganese was 12.59 mgkg^{-1}.

2.2 Effect of Industrial waste on ground water quality.

2.2.1 pH

Nangare (2008) studied the impact of textile industry effluent on ground water in Ichalkaranji City, Maharashtra and observed that the pH of water ranged from 6.5 to 9.0.

Kumar *et al.* (2011) studied the ground water assessment in paper mill effluents discharge area Namakkal district of Tamil Nadu and observed that the pH of water varied from 5.50 to 7.10.

Mahar *et al.*(2012) studied the effects of spent wash of ethanol industry on ground water quality at Rahimyar Khan District, Pakistan and observed that the pH of water varied from 6.8 to 7.7.

Agale (2013) studied the impact of sugar industry effluent on ground water from Dahiwad Village, Dhule district, Maharastra and observed that the pH of ground water varied from 7.1 to 8.5.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and observed that the pH of ground water as mean value was 7.70, 7.43 and 7.46 in summer, monsoon and winter seasons, respectively.

Madhukar and Srikantaswamy (2013) studied the impact industrial effluent on water quality in Bidadi industrial area of Karnataka, India and observed the pH of water varied from 7.3 to 8.4, 7.2 to 8.1 and 7.1 to 8.4 in pre-monsoon, monsoon and post-monsoon season, respectively.

Deshmukh (2014) studied the impacts of sugar mill effluents on the ground water from Sanganmer, Ahmednagar, Maharashtra and observed that the pH of water varied from 8.1 to 9.1.

Ramesh *et al.* (2014) studied the impacts of Tannery industry on ground water in Pallavaram Chennai Metropolitan city and observed the pH of ground water ranged from 6.1 to 8.0 in pre-monsoon and 5.8 to 7.8 in post-monsoon season.

Yadav *et al.* (2014) assessing variation in ground water of Digod tehsil of Kota district, Rajasthan, India and observed that the pH of water 8.3, 8.0 and 8.1 in pre, post-monsoon and winter season, respectively.

2.2.2 Electrical conductivity

Balakrishnan *et al.* (2008) studied the impacts of dye industrial effluents on the ground water quality in Kancheepuram district, Tamil Nadu and observed that the electrical conductivity of water varied from 1757 to 4210 μScm^{-1}.

Mahar *et al.*(2012) studied the effects of spent wash of ethanol industry effluents on ground water quality at Rahimyar Khan District, Pakistan and observed that the electrical conductivity of ground water varied from 0.47 to 6.91$mScm^{-1}$.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and observed that the electrical conductivity of ground water as mean value was 2.08, 1.73 and 1.12 mmhos/cm in summer, monsoon and winter season, respectively

Jesu*et al.*(2013) studied the impact of industrial effluent in ground water around Vaigai River at Anaipatti of Dindigul district, Tamil Nadu and observed that the electrical conductivity of ground water varied from 585 to 2750 $\mu mhoscm^{-1}$.

Madhukar and Srikantaswamy (2013) studied the effects of Bidadi industrial areaon ground water quality at Bangalore, Karnataka and that observed the electrical conductivity of ground water varied from 542 to 1481μScm^{-1} in pre-monsoon, 550 to 1345 μScm^{-1} in monsoon and 492 to 1251 μScm^{-1} in post-monsoon season.

Deshmukh (2014) studied the sugar mill effluents on ground water quality from Sangamner, Ahmednagar district of Maharashtra and found the electrical conductivity of ground water varied from 860 to 6470 μScm^{-1}.

Yadav *et al.* (2014) assessing variation in ground water of Digod tehsil of Kota district, Rajasthan, India and observed that the electrical conductivity of water 1140.2, 718.2 and 882.2 μScm^{-1} in pre, post-monsoon and winter season, respectively.

2.2.3 Carbonate and bicarbonate

Tripathi (2006) studied the impacts of polluted underground water from seepage of textile industrial effluents on soil properties in Jodhpur, Rajasthan and observed that the concentration of carbonate and bicarbonate in ground water were 84.0 meL^{-1} and 732.1 meL^{-1}, respectively.

Ayedun*et al.*(2012) studied the ground water quality around New Cement Factory, Ibese, Ogun State, Southwest Nigeria and observed that the bicarbonate concentration in ground water varied from 70 to 120 $mgL^{-1}$with a mean value was 94.0 mgL^{-1}.

Madhukar *et al.* (2013) studied the impact of industrial effluent on the water quality in Bidadi industrial area, Karnataka, India and found that the bicarbonate concentration was varied from 118 to 561 mg L^{-1}, 97 to 476 mg L^{-1} and 83 to 514 mg L^{-1} in during pre-monsoon, monsoon and post-monsoon, respectively.

Gupta *et al.* (2014) assessed the water quality in Peenya industrial area of Bangalore, India and observed that the bicarbonate concentration varied from 52 to 360 mg L^{-1}.

Deshmukh (2014) studied the impact of sugar mill effluents on quality of ground water from Sangamner, Ahmadnagar district of Maharashtra and observed the bicarbonate concentration varied from 141 to 665 mgL^{-1}.

Yadav *et al.* (2014) assessing variation in ground water of Digod tehsil of Kota district, Rajasthan, India and observed that the bicarbonate concentration was 570.1, 359.1 and 441.1 mg L^{-1} in during pre, post-monsoon and winter season, respectively.

2.2.4 Chloride

Rao *et al.* (2007) studied the temporal changes in ground water quality in an industrial area of Visakhapatnam, Andhra Pradesh and observed that the chloride concentration in ground water varied from 65 to 400 mg L^{-1}.

Nangare *et al.*(2008) studied the impact of textile industry on ground water quality at Ichalkaranji, Maharashtra and observed that the chloride concentration in ground water with a mean value of 114.5 mg L^{-1}.

Kumar *et al.* (2011) studied assessed the ground water quality in paper mill effluents irrigated area Kabilar Malai Union of Namakkal district, Tamil Nadu and found the concentration of chloride in ground water varied from 60.00 to 570 mg L^{-1}.

Agale (2013) studied the impact of sugar industry effluent on ground water from Dahiwad Village, Dhule district of Maharashtra and observed that the chloride concentration in ground water varied from 250 to 340 mg L^{-1}.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city of Haryana and observed that the concentration of chloride in ground water with a mean value were 104.33, 145.00 and 72.20 mg L^{-1}in summer, monsoon and winter season, respectively

Deshmukh (2014) studied the impact of sugar mill effluent on quality of ground water from Sangamner, Ahmednagar district of Maharashtra and observed that the chloride concentration in ground water ranged from 45 to 875 mg L^{-1}.

Singh *et al.* (2014) studied the impact of seasonal variation on physico-chemical parameters of Mansi-Ganga, Mathura, India and found that the chloride concentration a mean value was 1820.23, 122.06 and 1530.92 mg L^{-1} in during pre-monsoon, monsoon and post-monsoon seasons, respectively.

Yadav *et al.* (2014) Assessing variation in ground water of Digod tehsil of Kota district, Rajasthan, India and observed that the chloride in ground water was 90.6, 51.3 and 74.1 mg L^{-1} in during pre, post-monsoon and winter seasons, respectively.

2.2.5 Sodium

Rao *et al.*(2007) studied the temporal changes in ground water quality on industrial area of Visakhapatnam, Andhra Pradesh and observed the concentration of sodium in ground water varied from 14 to 533 mgL^{-1}.

Kumar *et al.*(2011) studied assessed the ground water quality in paper mill effluents irrigated area Kabilar Malai Union of Namakkal district, Tamil Nadu and found the concentration ofsodium in ground water varied from 70 to 512 ppm.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and observed that the concentration of Sodium in ground water as mean value was 88.33, 95.00 and 51.00 mgL^{-1}in summer, monsoon and winter season, respectively

Rao *et al.* (2013) studied the assessment of ground water quality of Ranipet industrial area of Tamil Nadu, India and found that the sodium concentration in water varied from 20 to 1010 mg L^{-1} and 16 to 54.1 mg L^{-1} in pre and post-monsoon season, respectively.

Deshmukh (2014) studied the impacts of sugar mill effluent on quality of ground water from Sangamner, Ahmednagar district, Maharashtra and observed that the sodium concentration in ground water varied from 6 to 184 g L^{-1}.

Yadav *et al.* (2014) Assessing variation in ground water of Digod tehsil of Kota district, Rajasthan, India and observed that the sodium concentration were 162.9, 97.4 and 131.3 mg L^{-1} in pre, post-monsoon and winter season, respectively.

2.2.6 Calcium

Rao *et al.*(2007) studied the temporal changes in ground water quality in an industrial area of Visakhapatnam, Andhra Pradesh and found that the concentration of calcium as average value in ground water was 110 to 570 mg L^{-1}.

Balakrishnan *et al.* (2008) studied the impact of dye industrial effluents on the ground water quality in Kancheepuram district of Tamil Nadu and observed the concentrations of calcium in ground water varied from 65 to 110 mg L^{-1}.

Ayedun *et al.*(2012) studied the ground water quality around New Cement Factory, Ibese, Ogun State, Southwest Nigeria and observed that the calcium concentration in ground water varied from 3.9 to 20.1 mg L^{-1} with a mean value 12.68 mg L^{-1}.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and observed that the concentration of calcium in ground water with a mean value of 106.67, 136.66 and 46.00 mg L^{-1} in summer, monsoon and winter season, respectively.

Jesu *et al.*(2013) studied the impact that of industrial effluent in ground water around Vaigai River at Anaipatti of Dindigul district, Tamil Nadu and observed the concentration of calcium in ground water varied from 45 to 280 mg L^{-1}.

Deshmukh (2014) studied the impact of sugar mill effluent on quality of ground water from Sangamner, Ahmednagar district, Maharashtra and observed the concentration of calcium in ground water ranged from 72 to 429 mg L^{-1}.

Yadav *et al.* (2014) Assessing variation in ground water of Digod tehsil of Kota district, Rajasthan, India and observed the concentration of calcium was 290.4, 191.5 and 234.2 mg L^{-1} in during pre, post-monsoon and winter season, respectively.

2.2.7 Magnesium

Rao *et al.*(2007) studied the temporal changes in ground water quality in an industrial area of Visakhapatnam, Andhra Pradesh and found that the concentration of magnesium in ground water varied from 15 to 113 mg L^{-1}.

Adekunle (2009) studied the effects of industrial effluents on quality of well water at Asa Dam industrial Estate, IIorin, Nigeria and found that the concentration of magnesium in water varied from 3 to 37 mg L^{-1}.

Ayedun *et al.*(2012) studied the ground water quality around New Cement Factory, Ibese, Ogun State, Southwest Nigeria and observed that the magnesium concentration in ground water varied from 0.29 to 6.23 mg L^{-1} with a mean value 4.116 mg L^{-1}.

Agale *et al.*(2013) studied the impact of sugar industry effluents on the quality of ground water from Dahiwad Village, Dhule district, Maharashtra and found that the concentration of magnesium in ground water varied from 30 to 50 mg L^{-1}.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and observed that the concentrations of magnesium in ground water with a mean value of 92.67, 88.00 and 32.40 mg L^{-1} in summer, monsoon and winter season, respectively.

Deshmukh (2014) studied the impact of sugar mill effluent on quality of ground water from Sangamner, Ahmednagar district, Maharashtra and observed the concentration of magnesium in ground water ranged from 7 to 261 mg L^{-1}.

Yadav *et al.* (2014) Assessing variation in ground water of Digod tehsil of Kota district, Rajasthan, India and observed the concentration of magnesium was 193.6, 106.4 and 140.6 mg L^{-1} in during pre, post-monsoon and winter season, respectively.

2.2.8Sodium Adsorption Ratio

Tripathi (2006) studied the impacts of polluted underground water from seepage of textile industrial effluents on soil properties in Jodhpur, Rajasthan and observed that the Sodium Adsorption Ratio of ground water as mean value 44.4.

Balakrishnan *et al.* (2008) studied the impact of dyeindustrial effluents on the ground water quality in Kancheepuram district, Tamil Nadu and observed the Sodium Adsorption Ratio in ground water varied from 2.80 to 5.99.

Banjare and Gupta (2010) assessed the seasonal variation of irrigation water suitability of Damodar River in West Bengal, India and observed that the Sodium adsorption Ratio with a mean value of 0.732, 0.756 and 0.679 during pre-monsoon, monsoon and post-monsoon season, respectively.

Kumar *et al.*(2011) studied assessed the ground water quality in paper mill effluents irrigated area Kabilar malai Union of Namakkal district, Tamil Nadu and found the Sodium Adsorption Ratio rangedfrom 6.48 to 18.02.

Ayedun*et al.*(2012) studied the ground water quality around New Cement Factory, Ibese, Ogun State, Southwest Nigeria and observed the Sodium Adsorption Ratio of ground water varied from 2.61 to 10.24 with a mean value of 7.65.

Jain and Bhadra (2012) Assessment the groundwater quality for irrigation purpose, Nainital district, Uttarakhand, India and found that the Sodium Adsorption Ratio was varied from 0.03 to 0.53 and 0.02 to 0.51 in pre and post-monsoon season, respectively.

Noel and Rajan (2012) studied the impact of Dye industry effluent on ground water quality at Chinnalapatti, Dindigul district, Tamil Nadu and observed that the Sodium Adsorption Ratio of ground water was 3.38.

2.2.9 Residual Sodium Carbonate

Banjare and Gupta (2010) assessed the seasonal variation of irrigation water suitability of Damodar River in West Bengal, India and observed that the RSC with a mean value of 0.236, 0.373 and -0.443 in during pre-monsoon, monsoon and post-monsoon, respectively.

Jain *et al.* (2012) studied the ground water quality for irrigation purpose, Nainital district, Uttarakhand, India and found the RSC value varied from -3.72 to 0.02 and -1.75 to 0.06 meq L^{-1} in during pre and post-monsoon season, respectively.

2.3 Effects of heavy metals on soil and ground water quality.

2.3.1 Heavy metals in soil

2.3.1.1 Nickel

Roy *et al.* (2008) studied the effect of paper industry waste water affected soil in three seasons nearby Nagpur district of Maharashtra and found that concentration of heavy metals nickel in waste water and well water irrigated surface soil varied from 0.538 to 0.698 mg kg^{-1} with a mean value of0.625 mg kg^{-1} and 0.236 to 0.297 mg kg^{-1} with a mean value 0.267 mg kg^{-1}, respectively.

Parth *et al.*(2011) assessed the heavy metals contamination in soil around waste disposal site in Hyderabad and found that the nickel concentration varied from 12.5 to 131.9 mg kg^{-1}.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and found the concentration of nickel in soil as mean value were 10.47 ppm, 7.63 ppm and 5.78 ppm in summer, monsoon and winter season, respectively.

2.3.1.2 Chromium

Roy *et al.* (2007) Effect of sugar factory effluent on some physico-chemical properties of soil and observed that the concentration of chromium in waste water irrigated soil was 0.164, 0.254 and 0.405 mg kg^{-1} during summer, rainy and winter season, respectively while well water irrigated soil contain 0.062, 0.034 and 0.094 mg kg^{-1} in summer, rainy and winter season, respectively.

Mwegoha and Kihampa (2010) studied the heavy metals contamination in surface and sub-surface soil and water in Dar es Salaam city, Tanzania and found that the concentration of chromium was varied from 174.707 to 502.33 mg kg^{-1}.

Parth *et al.*(2011) assessed the heavy metals contamination in soil around waste disposal site on Hyderabad and found thechromium concentration in soil ranged between 12.2 to 480.5 mg kg^{-1}.

Thambavani and Prathipa (2012) studied the heavy metals contamination of soil of Dindugul town, Tamilnadu and observed that a mean concentration of chromium in soil was 2.85 mg kg^{-1}.

2.3.1.3 Cobalt

Roy *et al.* (2008) studied the effect of paper industry waste water affected soil in three seasons nearby Nagpur district, Maharashtra and found that concentration ofcobalt in waste water and well water irrigated surface soil varied from0.218 to 0.516 mg kg^{-1} with a mean value of 0.362 mg kg^{-1} and 0.057 to 0.093 mg kg^{-1} with a mean value 0.069 mg kg^{-1}, respectively.

Sonawane *et al.* (2011) studied the seasonal variation of some micronutrient in soil around Kurkhumbh industrial area, Daund, Pune district of Maharashtra and observed that the cobalt concentration in soil varied from 0.9 to 79.6 mg kg^{-1} and 9.5 to 170 mg kg^{-1} durind pre and post-monsoon season, respectively.

Ladwani *et al.*(2012) studied the impact of industrial effluent on agricultural soil around Iron and steel industry at Bhandara, Maharashtra and observed that the concentration of cobalt in surface soil was16 to 40 mg kg^{-1}, respectively.

2.3.1.4 Lead

Roy *et al.* (2007) Effect of sugar factory effluent on some physico-chemical properties of soil and observed that the concentration of chromium in waste water irrigated soil was 0.006, 0.009 and 0.004 mg kg^{-1} during summer, rainy and winter season, respectively while well water irrigated soil contain 0.001, 0.001 and0.001 mg kg^{-1} in summer, rainy and winter season, respectively.

Roy *et al.* (2008) studied the paper industry waste water affected soil in three seasons nearby Nagpur district, Maharashtra and found that concentration of Pb in waste water and well water irrigated surface soil varied from 1.301 to 4.822 mg kg^{-1} with a mean value 2.721 mg kg^{-1} and 0.313 to 0.963 mg kg^{-1} with a mean value 0.560 mg kg^{-1}, respectively.

Parth *et al.*(2011) assessed the heavy metals contamination in soil around waste disposal site on Hyderabad and found that the lead concentration in soil was42.9 to 1833.5 mg kg^{-1}.

Samuel and Muthukkaruppam (2011) studied the sugar mill effluents contaminated soil at Cudalore and observed the concentration of heavy metal lead in soil was 0.53 ppm.**2.3.2 Heavy metals concentration in ground water**

2.3.2.1 Iron

Ayedun *et al.*(2012) studied the ground water quality around New Cement Company, Ibese, Ogun State of Southwest Nigeria and found the concentration of iron a mean value was 0.01 mg L^{-1} in in ground water.

Islam *et al.* (2012) studied the effects of solid waste and industrial effluents on water quality of Turag river at Konabari industrial area, Gazipur, Bangadesh and found that theiron concentration in water a mean value of 2.22 ppm.

Kumar *et al.*(2012) studied that the effects of textile effluents disposal on water quality of sub canal of upper canal at Haridwar, India and observed that the concentration of iron was 0.06 mg L^{-1} in sub-canal water before the confluence. At confluence their concentration was increased 4.56 mg L^{-1}.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and found that the concentrations of heavy metal irona mean value were 3.77 ppm, 1.50 ppm and 1.63 ppm in summer, monsoon and winter season, respectively.

Jesu *et al.*(2013) studied the impacts of industrial effluent in ground water around Vaigai River at Anaipatti of Dindigul district, Tamil Nadu and observed that the concentration of heavy metals iron varied from 0.07 to 1.0 mg L^{-1}.

Madhukar *et al.*(2013) studied the impacts of industrial effluents on the water quality at Bidadi industrial area, Bangalore, Karnataka and observed that the iron concentrations a mean value were 1.172 mg L^{-1} in pre-monsoon, 0.909 mg L^{-1} in monsoon and 0.831 mg L^{-1} in post-monsoon season.

2.3.2.2 Zinc

Mondol *et al.* (2011) studied the seasonal variation of heavy metal concentration in water an around Tejgaon industrial area of Bangladesh and observed that the zinc concentration in ground water varied from 0.02 to 0.08 mg L^{-1} and 0.00 to 0.348 mg L^{-1} in wetand dry season, respectively.

Islam *et al.* (2012) studied the effects of solid waste and industrial effluents on water quality of Turag River at Konabari industrial area, Gazipur, Bangadesh and observed that thezinc concentration in water as average value was 0.14 ppm.

Kumar *et al.*(2012) studied that the effects of textile effluents disposal on water quality of sub canal of upper canal at Haridwar, India and observed that the concentration of Zn was 0.5 mg L^{-1}in sub canal water before the confluence. At confluence their concentration was increased 1.34 mg L^{-1}.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and found that the concentrations of heavy metalsof zinc as mean value was 0.20 ppm, 0.13 ppm and 0.13 ppm in summer, monsoon and winter season, respectively.

Madhukar *et al.*(2013) studied the impacts of industrial effluents on the water quality at Bidadi industrial area, Banglore, Karnataka and observed that the concentration of zinc as mean value was 1.444 mg L^{-1} in pre-monsoon, 0.955 mg L^{-1} in monsoon and 1.132 mg L^{-1} in post-monsoon season.

2.3.2.3 Copper

Balakrishnan *et al.* (2008) studied the impact of dyeing industrial effluents on the ground water quality in Kancheepuram district, Tamil Nadu and observed that the concentration of heavy metalcopper in water varied from 0.01 to 0.6mg L^{-1}.

Ayedun *et al.*(2012) studied the ground water quality around New Cement Company, Ibese, Ogun State, Southwest Nigeria and found the concentration of copper a mean value was 0.01 mg L^{-1} in in ground water.

Islam *et al.* (2012) studied the effects of solid waste and industrial effluents on water quality of Turag River at Konabari industrial area, Gazipur, Bangadesh and observed that the concentration of heavy metalcopper a mean value of 0.07 mg L^{-1}.

Kumar *et al.*(2012) studied that the effects of textile effluents disposal on water quality of sub canal of upper canal at Haridwar, India and observed that the concentration of heavy metals Cua mean value of 0.06 mg L^{-1}sub canal water before the confluence. At confluence their concentration increased 2.88 mg L^{-1}.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and found that the concentrations of heavy metal copper as mean value was 0.44 ppm, 0.41 ppm and 0.29 ppm in summer, monsoon and winter season, respectively.

2.3.2.4 Manganese

Balakrishnan *et al.* (2008) studied the impact of dyeing industrial effluents on the ground water quality in Kancheepuram district, Tamil Nadu and observed that the concentration of heavy metal manganese in watervaried from 0.03 to 0.2 mg L^{-1}.

Ayedun *et al.*(2012) studied the ground water quality around New Cement Company, Ibese, Ogun State, Southwest Nigeria and found the concentration of manganese a mean value of0.02 mg L^{-1} in ground water.

Kumar *et al.*(2012) studied that the effects of textile effluents disposal on water quality of sub canal of upper canal at Haridwar, India and observed that the concentration of heavy metalmanganese varied from 0.02 mg L^{-1}in sub canal water before the confluence. At confluence their concentration increased 0.68 mg L^{-1}.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and found that the concentrations of heavy metal manganese a mean value of 0.55 ppm, 0.37 ppm and 0.28 ppm in summer, monsoon and winter season, respectively.

Jesu *et al.*(2013) studied the impacts of industrial effluent in ground water around Vaigai River at Anaipatti of Dindigul district, Tamil Nadu and observed that the concentration of manganeseranged between 0.05 to 0.1 mg L^{-1}.

Madhukar *et al.*(2013) studied the impacts of industrial effluents on the water quality at Bidadi industrial area ofBangalore, Karnataka and observed that the manganeseconcentration in water a mean value of 0.363 mg L^{-1} in pre-monsoon, 0.027 mg L^{-1} in monsoon and 0.302 mg L^{-1} in post-monsoon.

2.3.2.5 Nickel

Reza *et al.* (2009) studied the pre and post-monsoon variation of heavy metal concentration in ground water at Angul-Talcher region of Orissa, India and observed that the nickel concentration in ground water varied from 0.01 to 0.012 mg L^{-1} with a mean value of 0.030 mg L^{-1} and 0.009 to 0.08 mg L^{-1} with a mean value of 0.027mg L^{-1} in pre and post-monsoon season, respectively.

Ayedun *et al.*(2012) studied the ground water quality around New Cement Company, Ibese, Ogun State, Southwest Nigeria and found the concentration of heavy metals nickel in water a mean value of 0.01 mg L^{-1}.

Kumar *et al.*(2012) studied that the effects of textile effluents disposal on water quality of sub canal of upper canal at Haridwar, India and observed that the concentration of heavy metals manganese varied from 0.03 mg L^{-1}in sub canal water before the confluence. At confluence their concentration increased 1.76 mg L^{-1}.

Bharti *et al.* (2013) studied the impact of industrial effluents on ground water and soil quality in the vinicity of industrial area of Panipat city, Haryana and found that the nickel concentration a mean value was 0.15 ppm, 0.09 ppm and 0.05 ppm in summer, monsoon and winter season, respectively.

2.3.2.6 Chromium

Balakrishnan *et al.* (2008) studied the impact of dyeing industrial effluents on the ground water quality in Kancheepuram district, Tamil Nadu and observed that the concentration of heavy metals Cr in water was varied from 0.02 to 0.9 mg L^{-1}.

Jerome *et al.* (2010) studied the heavy metal concentration risk of ground water on industrial area of Bangalore, India and found that the chromium concentration in ground water a mean value of 1.60 mg L^{-1} and 2.93 mg L^{-1} in pre and post-monsoon season, respectively.

Mondol *et al.* (2011) studied the seasonal variation of heavy metal concentration in water an around Tejgaon industrial area of Bangladesh and observed that the chromium concentration in ground water varied from 0.002 to 0.092 mg L^{-1} and 0.02 to 0.10 mg L^{-1} in wetand dry season, respectively.

Kumar *et al.*(2012) studied that the effects of textile effluents disposal on water quality of sub canal of upper canal at Haridwar, India and observed that the concentration of heavy metals chromium was not detectedin sub canal water before the confluence. At confluence their concentration increased as 1.12mg L^{-1}.

Madhukar *et al.*(2013) studied the impacts of industrial effluents on the water quality at Bidadi industrial area ofBangalore, Karnataka and observed that the concentration of chromium in water a mean value of 0.017 mg L^{-1} in pre-monsoon, 0.01 mg L^{-1}in monsoon and 0.013 mg L^{-1}in post-monsoon.

2.3.2.7 Cobalt

Reza *et al.* (2009) studied the pre and post-monsoon variation of heavy metal concentration in ground water at Angul-Talcher region of Orissa, India and observed that the nickel concentration in ground water varied from 0.04 to 0.09 mg L^{-1} with a mean value of 0.065 mg L^{-1} and 0.004 to 0.01 mg L^{-1} with a mean value of 0.007mg L^{-1} in pre and post-monsoon season, respectively.

Jerome *et al.* (2010) studied the heavy metal concentration risk of ground water in an industrial area of Bangalore, India and found that the cobalt concentration in ground water varied from 0 to

0.20 mg L^{-1} and 0 to 0.17 mg L^{-1}, respectively in pre and post-monsoon season.

2.3.2.8 Lead

Kumar *et al.*(2012) studied that the effects of textile effluents disposal on water quality of sub canal of upper canal at Haridwar, India and observed that the concentration of heavy metallead was not detected in sub canal water before the confluence. At confluence their concentration increased 0.89 mg L^{-1}.

Madhukar *et al.*(2013) studied the impacts of industrial effluents on the water quality at Bidadi industrial area ofBangalore, Karnataka and observed that the concentration ofleadconcentrations a mean value of 0.102 mg L^{-1} in pre-monsoon, 0.065 mg L^{-1} in monsoon and 0.088 mg L^{-1} in post-monsoon.

CHAPTER III

MATERIAL AND METHODS

The present investigation entitled, "Effects of factory waste on soil and ground water quality from Lote M.I.D.C." was carried out in the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. BalasahebSawantKonkanKrishiVidyapeeth, Dapoli during the academic year 2013-2015. The material used and methods followed in the study are given under following heads:

3.1 Material

3.1.1 Climate

The climate of study area is hot, humid with well-expressed three season *viz.*, summer (March to May), rainy (June to October) and winter (November to February). The region receives very high rainfall (above 3000 mm annually), with the highest amount of rainfall in the month of July. The mean daily temperature is about 20^0C throughout the year. Month of May is generally the hottest, with a mean maximum temperature of around 33^0C. During rainy season, humidity is as high as 90 to 98 percent. It is least in winter afternoon, when it may come down to about 60 per cent.

3.1.2 Soil

The lateritic and laterite soils cover an area of about 10.73 lakh hectares in southern Raigad and whole of Ratnagiri and Sindhudurg district (Kadrekar*et al.* 1981). The soils are sandy clay loam to clay in texture. The soils developed on granite and gneiss material contain more sand and less clay as compared to the soils derived from basalt. The soils are susceptible to erosion. Heavy rains coupled with steep slopes are attributed for accelerated soil loss from the region. Minerologically these soils have Kaolinite as a predominant clay mineral associated with some quantity of illite.

In general, the soils are acidic (pH 4.75 to 6.50, mean 5.6) with low electrical conductivity. The cation exchange capacity ranges from 8.1 to 23.55 meq100^{-1} g of soil and generally increases with depth. The soils are fairly well supplied with organic carbon (0.60 to 2.32 per cent) and total nitrogen (0.09 to 0.26 per cent). The available phosphorous content is low. The phosphate fixing capacity is considerably high owing to high Fe and Al content. The available potassium content is variable and ranges from low to high.

The main cereal crops grown are rice, finger millet, lablab bean, horse gram, red gram, red cow pea and sesame. The horticultural crops Mango, Cashew, Coconut, Arecanuts, Jack fruit, Kokum and Banana are grown in these districts. In the recent years, rapid increase has been observed in the area of cultivation of horticultural crops in general and Mango and Cashew in particular. This has helped to raise the agricultural potential of this region (Anonymous, 1992).

3.1.3 Study area

The study area includes parts of Lote M.I.D.C.in Ratnagiri district. The Ratnagiri district is geographically situated in latitude of 16.58^0 to 16.98^0 N and 73.180^0 to 73.30^0E longitudes.

The study area Lote M.I.D.C. is situated 45 Km away from College of Agriculture, Dr. BalasahebSawantKonkanKrishiVidyapeeth Dapoli (Maharashtra) on Mumbai-Goa National Highway. The list of industries is given in Table 1.

Table1. Some industries assessed and their respective production activities

Industries	Production Activities
Gharda Chemical Ltd.	Produce Agrochemical
Hindustan Unilever Ltd.	Detergent Powder and Soap
PentokeyOrgany Ltd.	Acetic acid, Petroleum Ether
Kansai Nerolac Paint	Synthetic Resins, Paints
Aimko Pesticides Ltd.	Pesticides, Fungicide
Deepak chemtax Ltd.	Acid Dyes
Excel Industries Ltd.	Phosphorous Trichloride
Vinati Organics Ltd.	Sodium salt of Methyl AllylSuphonic Acid
India Oxalate Ltd.	Oxalate Acid
Shree Pushkar Petro Pvt.Ltd.	Polyester Resins (Saturated)
S.R. Drugs Pvt. Ltd.	Diethyl Oxalate
Sandvik Asia Ltd.	Machine Tools Material
SI Group India Ltd.	Phenolic & Alkyl PhenolicResins
Dow AgroSciencesPvt Ltd.	Pesticide
Deepak Novochem. Ltd	Cresols &Xylenols

3.1.4 Collection of samples

3.1.4.1 Collection and preparation of soil samples

The surface soil samples were collected twice viz. before the monsoon, in the month of June and after the monsoon, in the month of October. The surface soils were collected from mango and coconut orchards from Awashi village. In the mango orchard, waste is beingdumped and coconut orchard is being irrigated with polluted water. Sample No. 1 to 9 is taken from mango orchard and Sample No. 10 to 15 from coconut orchard.

All the surface soil samples were air dried under shed in an open room. Then the impurities like stones, pebbles, roots, dried leaves etc. were removed and the soil samples were ground in wooden mortar and pestle and sieved through 2 mm and 0.5 mm sieve for special determination like soil organic carbon. The processed soil samples were kept in polythene bags and finally in corrugated boxes, labeled properly and used for analysis.

3.1.4.2 Collection and preparation of water sample

Water sample were collected at one month interval for one year (April 2014 to March 2015) from the wells, which were situated around the industrial area. Twenty water samples were collected every month. These water samples were collected in clean plastic and transparent bottles.

The water samples were analyzed immediately after collection from the wells. The samples were stored in refrigerator at $4^{0}C$ or added two to three drops of Toluene for prevention of fungal or bacterial growth**.** The water samples were filtered through Whatman No. 42 filter paper before analysis.

3.2 Methods

The methods followed for determination of physico-chemical properties of soil and chemical properties of water are described below.

3.2.1 Soil analysis parameters

3.2.1.1 Soil reaction (pH)

The pH of soil samples was determined by using Systronic pH meter model 361 having combined electrode using 1:2.5 soil:water suspension ratio (Jackson, 1967). For the categorization of the soils analyzed, the category proposed by Sankaran (1966) was used (Table 2).

3.2.1.2 Electrical conductivity (EC)

Electrical Conductivity was determined with the help of Systronic Conductivity Meter-308 using 1:2.5 soils: water suspension ratio (Jackson, 1973).

3.2.1.3 Organic carbon

Organic carbon in the soil samples which were collected from the selected locations was determined according to theWalkley and Black wet oxidation method, (Black, 1965).

3.2.1.4 Available nitrogen

Available nitrogen in the soil samples was determined by alkaline permanganate (0.32% $KMnO_4$) method as described by Subbiah and Asija, 1956. The analyzed samples were categorized into different groups of available nitrogen as per the ranges proposed by Subbiah and Asija, 1956 (Table 3).

Table 2. Soil pH categorization proposed by Sankaran (1966).

Category	Ranges
Extremely Acid	Below 4.5
Strongly Acid	4.5-5.2
Moderately acid	5.3-5.8
Slightly Acid	6.0-6.5
Nearly Neutral	6.6-7.0
Slightly Alkaline	7.1-7.5
Moderately Alkaline	7.6-8.3
Strongly Alkaline	8.4-9.0
Extremely Alkaline	Above 9.0

Table 3. Available nitrogen (kg ha^{-1}) categorization proposed by Subbiah and Asija (1956).

Category	Available N (kg ha^{-1})
Very Low	< 140
Low	141 to 280
Medium	281 to 420
Moderately High	421 to 560
High	561 to 700
Very High	> 700

3.2.1.5 Available phosphorus

Available phosphorus in the soil samples collected from the selected locations was determined by Brays No. I method, by developing blue colour with ammonium molybdate and stannous chloride. Phosphorus was determined colorimetrically by using Spectrophotometer model ELICO SL 164 Double Beam at 660 nm wavelength as outlined by Black (1965).

3.2.1.6 Available potassium

Available Potassium was estimated in a Flame-photometer,Elico Model CL-361 using neutral-normal-ammonium acetate (NH_4OAc,pH 7.0) as per the procedure suggested by Jackson (1973).

The analyzed samples were categorized into different groups for organic carbon, available phosphorous, available potassium as per the ranges proposed by Bangar and Zende, 1978(Table 4).

Table 4.Organic carbon (per cent) and available P_2O_5, K_2O (kg ha^{-1}) categorization (Bangar and Zende, 1978).

Sr. No.	Category	Organic carbon (%)	Available P_2O_5(kg ha^{-1})	Available K_2O (kg ha^{-1})
1	Very Low	< 0.20	< 7	< 100
2	Low	0.21 to 0.40	7.1 to 14	101 to 150
3	Medium	0.41 to 0.60	14.1 to 21	151 to 200
4	Moderately High	0.61 to 0.80	21.1 to 28	201 to 250
5	High	0.81 to 1.00	28.1 to 35	251 to 300
6	Very High	> 1.00	> 35	> 300

3.2.1.7 Exchangeable calciumand magnesium

The exchangeable calciumand magnesiumwere determined titrimetrically by using 0.01N Ethylene Di-amine Tetra Acetic Acid (Versenate Method) as suggested by Chopra and Kanwar, 1978.

3.2.1.8 Available sulphur

Available sulphur was determined turbimetrically using soil: extractant in 1:5 proportion using 0.15 per cent $BaCl_2$ as an extractant. Turbidity developed by barium chloride was measured Spectrophotometrically at 340 nm wavelength as outlined by Chesnin and Yein, 1995.

3.2.1.9 Micronutrients

DTPA extractable micronutrient viz.,Fe, Cu, Zn and Mn were determined using Atomic Absorption Spectrophotometer (Perkin Elmer make model no. Aanyst 200) as outlined by Lindsay and Norvell, 1978.

3.2.1.10 Heavy metals

Nickel, chromium, cobalt and lead were determined using Atomic Absorption Spectrophotometer (Perkin Elmer make model No. Aanyst 200) as outlined by Lindsay and Norvell, 1978.

3.2.2 Water analysis parameters

3.2.2.1 pH

The pH of water was measured using Systronic pH meter, Model 361 as outlined by Jackson, 1967.

3.2.2.2 Electrical conductivity

Electrical conductivity (EC) is a measure of soluble salt concentration in solution. This ability depends on the presence of ions, their total concentration and temperature. EC of water was measured with the help of Systronic Conductivity Meter-308 as outlined by Jackson, 1973. The analyzed samples were categorized into different classes of water as per the ranges proposed by the United States Salinity Laboratory Staff, 1969(Table 5).

3.2.2.3 Carbonate and Bicarbonate

Carbonate and Bicarbonate of water was determined using standard sulphuric acid (Dilute acid titration) method as given by Hesse, 1971.

3.2.2.4 Chlorides

Chlorides were determined by titration of the sample with silver nitrateaccording to Mohr`s Titration Method.

3.2.2.5 Sodium

Sodium of water was determined using Systronic Flame Photometer as described by Jackson, 1973.

3.2.2.6 Calcium and Magnesium

The calcium and magnesium of water were determined by EDTA (Versanate) method using Di-sodium solution of Ethylene Di-amine Tetra Acetic Acid as described by Schwarzenbach*et al.*(1946).

Table 5.Electrical conductivity classification as proposed by The United States Salinity Laboratory Staff (1969).

Classes of Water	Electrical Conductivity (dSm^{-1} at 25^{0} C)
Class 1, Excellent	<0.25
Class 2, Good	0.25 - 0.75
Class 3, Permissible	0.76 - 2.00
Class 4, Doubtful	2.01 – 3.00
Class 5, Unsuitable	>3.00

3.2.2.7Sodium Adsorption Ratio (SAR)

Sodium Adsorption ratio was calculatedas the ratio of sodium content to the content of calcium plus magnesium in the water.

$$SAR = \frac{Na^{+}}{\sqrt{(Ca + Mg)}/2}$$

Where, Na^{+}, Ca^{+}, Mg^{+} are in $meqL^{-1}$ from the water analysis and was categorized according to the United States Salinity Laboratory Staff, 1969 (Table 6).

Table 6. Sodium Adsorption Ratio classification proposed by The United States Salinity Laboratory Staff, (1969).

Classes of Water	SAR

Low sodium water-S1	<10
Medium sodium water-S2	10-18
High sodium water-S3	18-26
Very high sodium water-S4	>26

3.2.2.8 Residual Sodium Carbonate

The RSC value is the calculated by following formula is given below:

RSC= [(HCO_3 +CO_3) - (Ca^{2+}+ Mg^{2+})]

Where, HCO_3^-, CO^-_3, Ca^{2+} and Mg^{2+} are in meq L^{-1}.

Table7. Residual Sodium Carbonate classification proposed by The United States Salinity Laboratory Staff, (1969).

Water Classes	RSC
Excellent	<1.25
Good	1.25-2.0
Medium	2.0-2.5
Bad	2.5-3.0
Very Bad	>3.0

Source: CGWB and CPCB (2000)

3.2.2.9 Heavy Metals

Heavy metals viz., Fe, Cu, Zn, Mn, Ni, Co,Pb and Cr from water were determined usingAtomic Absorption Spectrophotometer (Perkin Elmer make model no. Aanyst 200) as outlined by Lindsay and Norvell, 1978.

Table 8. Drinking water quality prescribed by Bureau of Indian Standard (1990) (mgL^{-1})

Parameter	Desirable Limit	Max. Permissible Limit
pH	6.5-8.5	No Relaxation
Bicarbonate (mg L^{-1})	200	600
Chloride (mg L^{-1})	200	1000
Calcium (mg L^{-1})	75	200
Magnesium (mg L^{-1})	30	150

Fe	0.3	1.0
Cu	0.05	1.5
Mn	0.05	0.5
Zn	0.5	5.0
Ni	0.02	No Relaxation
Cr	0.05	No Relaxation
Pb	0.05	No Relaxation

3.2.3 Statistical Analysis

The data obtained was processed with suitable statistical techniques by using the data analysis software SAS 9.3, ICAR-11601386.

CHAPTER IV
RESULTS AND DISCUSSION

In the present investigation an attempt has been made to study the “Effects of factory waste on soil and ground water quality from Lote M.I.D.C.”tahsil-Khed,Dist. Ratnagiri (M.S.). The analytical work was done in the research laboratory of the Department of Soil Science and Agricultural .Chemistry, College of Agriculture, Dr. BalasahebSawantKonkanKrishiVidyapeeth, Dapoli during the academic year 2014-2015. The observations and analytical values obtained during course of study were analyzed, described and contemplated to discuss the variations observed in the light of available evidences and literature. For brevity, the entire results and discussion has been divided into the following heads:

4.1 Physico-chemical properties of soil

4.2 Micronutrient and heavy metal concentration in soil

4.3 Physico-chemical properties of ground water

4.4 Micronutrient and heavy metal concentration in ground water

4.1 Physico-chemical properties of soil

4.1.1 pH

The data presented in Table 9 revealed that the pH of soil varied from 4.15 to 5.14 with an average value of 4.45 and 3.89 to 6.03 with a mean value of 4.50 inpre-monsoon season and post-monsoon season, respectively.The pH of uncontaminated soil was 4.67.

In general, lateritic soils are acidic in nature. The acidic nature of soil might be attributed to the leaching of soluble salts due to heavy precipitation in rainy season.In post-monsoon season,the soil pH is increased as compared pre-monsoon season due to addition of rain water (Solanki*et al.* 2012). The similar results of increased soil pH in post-monsoon season had been also reported by Bharti*et al.* (2013).

Table 9.Variation in soil pH at pre and post-monsoon season

pH		
Sample No.	**Pre- Monsoon**	**Post-Monsoon**
1	4.20	3.90
2	4.15	4.23
3	4.56	4.40
4	4.31	4.25
5	4.47	4.35
6	4.66	4.24
7	4.46	4.15
8	4.33	4.42
9	4.37	4.03
10	4.31	3.84
11	4.45	5.34
12	4.63	4.78
13	4.27	4.67
14	5.14	6.03
15	4.43	4.86
Mean	**4.45**	**4.50**
Range	**4.15-5.14**	**3.89-6.03**
Normal soil	**4.67**	

4.1.2 Electrical conductivity

The data related to electrical conductivityare given in Table 10.The electrical conductivity of soil in pre-monsoon varied from 0.051 to 0.094 $dSm^{-1}$with an average value of 0.067 dSm^{-1},while for post-monsoon season it showed variationfrom 0.047 to 0.114 $dSm^{-1}$with a mean value of 0.072 dSm^{-1}.Chitra*et al.*, (2011) also obtained the similar ranged from 0.06 to 0.20 dSm^{-1} in soil at sugar factory waste affected area in Cuddalore district, Tamil Nadu (India).The electrical conductivity of uncontaminated soil was 0.049 dSm^{-1}.

The electrical conductivity increasedin post-monsoon season as compared to pre-monsoon season. In laterite soil, when the water content increases electrical conductivity also increases (Kong *et al.*, 2013). Roy *et al.*, (2008) also reported the similar trends of increased soil electrical conductivity in post-monsoon season.

Table 10.Variation in soil electrical conductivity(dSm^{-1}) at pre and post-monsoon season

Electrical conductivity		
Sample No.	**Pre- Monsoon**	**Post- Monsoon**
1	0.074	0.100
2	0.055	0.047
3	0.068	0.062
4	0.054	0.055
5	0.051	0.058
6	0.073	0.103
7	0.057	0.051
8	0.094	0.053
9	0.075	0.046
10	0.074	0.069
11	0.056	0.061
12	0.052	0.092
13	0.085	0.104
14	0.066	0.114
15	0.077	0.067
Mean	**0.067**	**0.072**
Range	**0.051-0.094**	**0.047-0.114**
Normal soil	**0.049**	

4.1.3 Organic carbon

Organic carbon of soil is given in Table 11.The organic carbon in soil on pre and post- monsoon season ranged from 0.95 to 2.63 per cent with a mean value 1.94 per cent and 1.77 to 3.10 per cent with an average value 2.37 per cent, respectivelyindicating that the soils are 'very high' in organic carbon content.The organic carbon of uncontaminated laterite soil is 1.52 per cent.

In general, the organic carbon content in the lateritic soils of Konkan is in 'very high' range as per the ratings proposed by Bangar and Zende, (1978). The very high organic carbon content of the soil might be attributed to the hot and humid climate of the Konkan region.In general wetland soil has more organic carbon content than terrestrial soil becausepresences of soil microorganism are responsible for decomposition of organic matter (Ingavale*et al.*, 2012). The similar results of increased soil organic carbon in post-monsoon season have also been reported by Shivakumar*et al.*, (2012) in industrial area Mysore, Karnataka.

Table11. Variation insoil organic carbon (per cent)at pre and post-monsoon season

Organic carbon		
Sample No.	**Pre-Monsoon**	**Post- Monsoon**
1	2.33	3.07
2	2.25	2.84
3	0.95	2.21
4	1.12	3.10
5	2.63	2.99
6	2.25	1.77
7	2.19	1.98
8	2.07	1.98
9	1.30	1.77
10	2.54	2.39
11	2.27	2.07
12	1.15	2.57
13	2.54	2.72
14	1.09	2.13
15	2.42	1.89
Mean	**1.94**	**2.37**
Range	**0.95-2.63**	**1.77-3.10**
Normal soil	**1.52**	

4.1.4 Available nitrogen

The data (Table 12) indicated that the available nitrogen in soil for pre-monsoon season ranged from 235.20 to 454.72 kgha^{-1} with a mean value of 365.82 kgha^{-1},while an average value of 301.89 kg ha^{-1}during post-monsoon season and it ranged between 235.20 to 392.28kgha^{-1}.These soils are 'Low' to 'Moderate high' in available nitrogen content as per the standard ratings. The available nitrogen in uncontaminatedsoil was 444.80 kg ha^{-1}.

In pre-monsoon season,the available nitrogen content is higher than post-monsoon season due to mineralization of organic carbon that have released large amount of nitrogen in soil (Prasad *et al.*, 2008).Roy *et al.*, (2008) also reported that the available nitrogen was higher in pre-monsoon season on paper factory wasteaffected soil at Nagpur, Maharashtra.

Table12. Variation in available nitrogen (kg ha^{-1}) on soil at pre and post-monsoon season

Available nitrogen		
Sample No.	**Pre- Monsoon**	**Post- Monsoon**
1	329.28	282.24
2	424.24	392.28
3	392.00	282.24
4	423.36	250.88
5	407.68	376.32
6	390.28	313.60
7	344.96	326.45
8	235.20	297.28
9	321.5	282.24
10	344.96	297.92
11	360.64	360.64
12	313.60	297.92
13	454.72	282.24
14	352.70	250.88
15	392.28	235.20
Mean	**365.82**	**301.89**
Range	**235.20-454.72**	**235.20-392.28**
Normal soil	**444.80**	

4.1.5 Available phosphorus

Available phosphorus estimated from soil from different soil samples is given in Table 13. The available phosphorus in soil at various samples ranged from 3.55 to 13.51kgha^{-1} with a mean value of 6.87 kgha^{-1} and 3.12 to 8.97 kgha^{-1} with an average value of 5.78kgha^{-1} in pre and post-monsoon seasons, respectivelyindicating that these soils are 'low' in available phosphorous content. The available phosphorus content in uncontaminated soil was 4.80 kg ha^{-1}.

In general, the available phosphorous content in the lateritic soils of Konkan is in 'low' range. This is due to high phosphorus fixation capacity. The available phosphorous in lateritic soils of

Konkan region varied from 0.35 to 74.14 kg ha^{-1} with an average value of 14.14 kg ha-1 (Chavan, 1979; Dabke, 1987; Dongale, 1987; Anonymous, 1985). The similar trends of increased of available phosphorus in pre-monsoon season due to effect of industrial waste of near Nagpur, Maharashtra have been reported by Joshi *et al*., (2008).

Table 13.Variation in available phosphorus (kg ha^{-1}) on soil at pre and post-monsoon season

Available phosphorus		
Sample No.	**Pre- Monsoon**	**Post-monsoon**
1	4.98	4.03
2	6.16	5.21
3	3.55	6.87
4	6.40	7.11
5	13.51	5.92
6	8.77	4.98
7	6.63	4.50
8	5.92	3.79
9	7.35	5.21

10	6.40	7.11
11	4.98	3.45
12	4.50	3.12
13	6.16	4.87
14	5.45	4.03
15	12.32	8.97
Mean	**6.87**	**5.78**
Range	**3.55-13.51**	**3.12-8.97**
Normal soil	**4.80**	

4.1.6 Available potassium

The available potash content in soil is presented in Table 14.The available potassium in soil duringpre-monsoonseason varied from 114.24 to 302.20 $kgha^{-1}$ with a mean value of 168.37 $kgha^{-1}$,while for post-monsoon season it was 92.96 to 230.72 $kgha^{-1}$ with an average value of 130.58 $kgha^{-1}$.The range of available potassium of lateritic soils was in agreement with Anonymous (1990) and Joshi (2012).The available potassium was 236.70 kg ha^{-1} in uncontaminated soil.

In post-monsoon season,the potassium content decreased in soil as compared to pre-monsoon season.In rainy season the potassium present in soil is easily dissolved in water and eroded off. It clearly indicates that the solubility of potassium in rainy season is higher than in dry season (Srikantaswamy, 2012).The similar trends of decreased available potassium in soilduringpost-monsoon season have been reported by Prasad*et al.*,(2008).

Table14.Variation inavailable potassium (kg ha-1) on soil at pre and post-monsoon season

Available potassium		
Sample No.	**Pre- Monsoon**	**Post- Monsoon**
1	125.44	112.00
2	114.24	96.86
3	138.88	108.64
4	132.16	92.96
5	169.12	113.12
6	132.16	100.80
7	141.12	97.44
8	118.72	109.80
9	189.28	137.76
10	129.92	112.80
11	302.40	230.72
12	244.16	120.96
13	202.72	118.28
14	237.44	218.40
15	147.84	188.16
Mean	**168.37**	**130.58**
Range	**114.24-302.20**	**92.96-230.72**
Normal soil	**236.70**	

4.1.7 Exchangeable calcium

As seen from Table 15, the exchangeable calcium in soil during pre and post-monsoon season ranged from 1.60 to 8.10meq100^{-1} g with a mean value of 3.98 meq 100^{-1} g and 1.40 to 5.40meq 100^{-1}g with an average value of 2.91 meq 100^{-1} g, respectively.The calcium content is decreasedin post-monsoon season due to leaching losses of calcium with heavy rainfall.The exchangeable calcium in normal soil was 1.70 meq 100^{-1} g.

Shivakumar*et al.*, (2012) also found the similar results of decreased calcium content in soil during post-monsoon season on industrial area, Karnataka, India.

Table 15. Variation inexchangeable calcium (meq100^{-1} g) on soil at pre and post-monsoon season

Exchangeable calcium		
Sample No.	**Pre-Monsoon**	**Post- Monsoon**
1	1.70	2.30
2	1.60	1.40
3	3.20	1.90
4	3.00	2.10
5	4.60	1.50
6	3.50	1.40
7	2.10	2.00
8	2.80	3.10
9	3.10	2.30
10	2.80	2.00
11	8.10	7.30
12	7.80	5.40
13	4.30	3.10
14	5.70	3.60
15	5.40	4.20
Mean	**3.98**	**2.91**
Range	**1.60-8.10**	**1.40-5.40**
Normal soil	**1.70**	

4.1.8 Exchangeable magnesium

The exchangeable magnesium content in soil is presented in Table 16. In pre-monsoon season,the exchangeable magnesium ranged between 0.00 to 2.10meq 100^{-1}g with a mean value of 0.82 meq 100^{-1}g,while in post-monsoon season it varied from 0.00 to 1.80 meq 100^{-1}g with an average value of 0.65 meq 100^{-1}g. In normal soil, the exchangeable magnesium was 1.23 meq 100^{-1} g.

In post-monsoon season,the magnesium content in soil decreased as compared to pre-monsoon season due to leachingthrough heavy rainfall (Kumar *et al.* 2012). Srikantaswamy*et al.*, (2012) also found the similar results in industrial area of Mysore city, Karnataka.

Table 16. Variation inexchangeable magnesium (meq 100^{-1} g) on soil at pre and post-monsoon season

Exchangeable Magnesium		
Sample No.	**Pre- Monsoon**	**Post- Monsoon**
1	0.40	0.40
2	0.60	0.20
3	0.60	0.00
4	1.00	0.80
5	0.20	0.40
6	1.00	0.50
7	0.40	0.30
8	0.30	0.60
9	0.30	0.30
10	0.00	0.70
11	1.50	0.90
12	2.10	1.80
13	1.70	1.30
14	1.30	0.90
15	0.90	0.60
Mean	**0.82**	**0.65**
Range	**0.00-2.10**	**0.00-1.80**
Normal soil	**1.23**	

4.1.9 Available sulphur

As seen from Table 17,indicated the available sulphur in soil during pre-monsoon seasonvaried from 2.42 to 13.21 mgkg^{-1} with a mean value of 7.82 mgkg^{-1},while in post-monsoon season10.20 mg kg^{-1} was an average value of sulphur and it ranged between 1.21 to 18.17 mgkg^{-1}.Rajbala*et al.*, (2012) also found the similar range of available sulphur. Ghosh*et al.*, (2012) also observed the available sulphur varied from 16.2 to 35.0 mg kg^{-1} with a mean value of 29.5 mg kg^{-1} in laterite soil of West Bengal, India.In uncontaminated soil the available sulphur content was 10.20 mgkg^{-1}.

In post-monsoon season,the sulphur content was higher in soil as the rainfall might have added a significant amount of atmospheric sulphurin soil (Jones *et al.*, 1982; Blair *et al.*, 2005), but the amount deposited varies from one place to another, being higher near the industrial areas (Wang *et al.*, 2005).

Table 17. Variation inavailable sulphur (mg kg^{-1}) on soil at pre and post-monsoon season

Available sulphur		
Sample No.	**Pre- Monsoon**	**Post- Monsoon**
1	2.42	4.84
2	8.75	12.39
3	6.06	18.17
4	3.63	1.21
5	6.66	12.72
6	11.51	15.14
7	5.45	12.11
8	7.87	8.48
9	7.87	4.84
10	5.45	2.42
11	9.21	6.66
12	9.69	7.27
13	11.51	16.35
14	13.21	16.58
15	7.27	15.14
Mean	**7.82**	**10.29**
Range	**2.42-13.21**	**1.21-18.17**
Normal soil	**10.20**	

4.2 Micronutrient and heavy metal concentration in soil

4.2.1 DTPA-extractable Iron

The available (DTPA-extractable) iron concentration in soil is presented in Table 18. In pre and post-monsoon seasons, the available iron concentration in soil ranged from 29.52 to 147.88 mgkg^{-1} with a mean value of 80.70 mgkg^{-1} and 42.28 to 132.32 mgkg^{-1} with an average value of 77.52 mgkg^{-1}, respectively.Bhosle*et al.*, (2013) obtained the mean iron concentration 60 mg kg^{-1} in soil near the Siddheshwar Dam, Maharashtra, India. In present study, the iron concentration was found in soil samples below the maximum permissible limit (ISI, 1996).The available (DTPA-extractable) iron content in uncontaminated soil was 41.76 mg kg^{-1}.

In post-monsoon season,the available iron concentration decreased in soil as compared to pre-monsoon season. The iron concentration is high due to their cumulative and adsorptive nature in soil after irrigation by contaminated ground water (Satake, 2003). Roy *et al.*, (2008) also reported the similar results of decreased iron concentration during post-monsoon season inpaper industry waste affected soil near Nagpur, Maharashtra, India.

Table18. Variation iniron concentration (mg kg^{-1}) on soil at pre and post-monsoon season

Available iron		
Sample No.	**Pre- Monsoon**	**Post- monsoon**
1	56.84	42.28
2	47.12	58.76
3	29.52	57.44
4	62.32	86.04
5	80.64	44.60
6	48.80	51.20
7	63.56	42.84
8	95.59	77.60
9	71.56	43.16
10	73.40	56.44
11	102.76	126.92
12	147.88	132.88
13	134.72	132.32
14	112.28	118.04
15	83.48	92.20
Mean	**80.70**	**77.52**
Range	**29.52-147.88**	**42.28-132.32**
Normal soil	**41.76**	

4.2.2 DTPA-extractable Zinc

The data presented on available (DTPA-extractable) zinc concentration in soil (Table 19)varied from 0.02 to 1.45mg kg^{-1} with a mean value of 0.60 mgkg^{-1}in pre-monsoon season and 0.02 to 10.69

mgkg^{-1} with an average value of 2.76 mgkg^{-1} in post-monsoon season.The result was supported by finding of Patel *et al.*, (2015) for surface soil around Vapi industrial area, Gujarat. The zinc concentration is found minimum due to its weak adsorptive nature in soil (Satake, 2003).According to ISI, (1996) the zinc concentration observed in all contaminated soil samples below the maximum permissible limit.In uncontaminated soil the available zinc content was 1.32 mg kg^{-1}.

In post-monsoon season,the available zinc concentration increased in soil. Moon *et al.*, (1991) also observed the effluent of industries increased zinc status in soil.The similar results of increased zinc concentration in soil on post-monsoon season due to effect of sugar factoryeffluentson Hinganghattahsil of Wardha, Maharashtra have also been reported by Prasad *et al.*, (2007).

Table 19. Variation inzinc concentration (mg kg^{-1}) on soil at pre and post-monsoon season

	Available zinc	
Sample No.	**Pre-Monsoon**	**Post-Monsoon**
1	0.06	0.05
2	0.06	4.29
3	0.05	0.03
4	0.04	0.02
5	0.06	0.06
6	0.03	2.95
7	1.45	3.13
8	0.03	3.29
9	0.03	4.08
10	0.02	3.71
11	0.05	2.79
12	0.04	1.80
13	6.95	10.69
14	0.05	2.15
15	0.05	2.44
Mean	**0.60**	**2.76**
Range	**0.02-6.95**	**0.02-10.69**
Normal soil	**1.32**	

4.2.3 DTPA-extractable Copper

As seen from Table 20, the copper concentration in soil ranged from 2.18 to 7.07 $mgkg^{-1}$ with a mean value of 4.94 $mgkg^{-1}$in pre-monsoon season and it ranged between 4.24 to 8.63 $mgkg^{-1}$ with an average value of 6.19 $mgkg^{-1}$during post-monsoon season. In present study, the copper concentration all soil samples werebelow the maximum permissible limit (ISI, 1996).The copper content was found 1.57 mg kg^{-1} in uncontaminated soil.

After the monsoon copper concentration increased in soildue to contamination with industrial wastes that percolated in soil through rain water (Mustafa *et al.*, 2012).Prasad *et al.*, (2007) also found the similar ranges in soil affected with factory effluent near Wardha district of Maharashtra, India.

Table 20. Variation incopper concentration (mg kg^{-1}) on soil at pre and post-monsoon season

Available copper		
Sample No.	**Pre-Monsoon**	**Post- Monsoon**
1	3.90	4.24
2	3.67	6.46
3	2.18	5.93
4	6.19	5.94
5	4.20	4.73
6	4.31	4.56
7	4.19	4.77
8	6.50	5.26
9	5.50	5.17
10	4.83	5.09
11	6.39	8.02
12	2.49	8.05
13	7.07	8.63
14	6.11	7.38
15	6.60	8.60
Mean	**4.94**	**6.19**
range	**2.18-7.07**	**4.24-8.63**
Normal soil	**1.57**	

4.2.4 DTPA-extractable Manganese

The data (Table 21) indicated that the available manganese concentration in soilduring pre-monsoonvaried from 22.68 to 128.36 mgkg^{-1} with a mean value of 53.11 mgkg^{-1} and 14.96 to 97.96 mgkg^{-1} with an average value of 53.17 mgkg^{-1}during post-monsoon season. Gupta *et al.*, (2002) also observed the presence of manganese concentration in the range of 26.40 to 66.00 mg kg^{-1} in Kolkata, when soils were irrigated with different industrial effluents.In normal soil the available manganese content was 50.81 mg kg^{-1}.

In post-monsoon,the manganese concentration increased in soil as compared to pre-monsoon season. Thesimilar observation of increased manganeseconcentrationduring post-monsoon season reported by Prasad*et al.*, (2008).

Table 21. Variation inmanganese concentration (mg kg^{-1}) on soil at pre and post-monsoon season

Available manganese		
Sample No.	**Pre-monsoon**	**Post-Monsoon**
1	29.88	14.96
2	22.68	44.28
3	40.84	33.48
4	68.32	30.04
5	35.72	17.12
6	53.56	52.24
7	25.04	59.12
8	78.84	72.12
9	59.76	97.96
10	53.56	64.64
11	60.40	66.36
12	34.92	44.12
13	49.68	97.76
14	128.36	59.76
15	55.08	43.60
Mean	**53.11**	**53.17**
Range	**22.68-128.36**	**14.96-97.96**
Normal soil	**50.81**	

4.2.5Nickel

The nickel concentration in soil is presented in Table 22. The nickel concentration in soil during pre-monsoon varied from 0.21 to 2.03 mg $kg^{-1}$with a mean value of 0.96 mg kg^{-1}, while 0.69 mg kg^{-1} was an average value and it ranged between 0.26 to 1.13 mg kg^{-1}in post-monsoon season. The similar range of nickel concentration in soil irrigated with paper factory effluent hasbeen reported by Joshi *et al.*, (2008). The data was also supported by Patel *et al.*, (2015) in soil near the industrial area of Gujarat, India.

The maximum permissible limit of nickel for soil is 80 ppm (ISI, 1996). The present experimental data showed all the samples contain nickel concentration below the maximum permissible limit in both pre and post-monsoon season.

The similar observations of decreased nickel concentration in soil during post-monsoon season due to effect of industrial waste in Ranipat city, India have been reported by Bharti*et al.*, (2013).

Table 22. Variation innickel concentration (mg kg^{-1}) on soil at pre and post-monsoon season

Available nickel		
Sample No.	**Pre-Monsoon**	**Post-Monsoon**
1	0.35	0.26
2	0.81	0.60
3	1.54	0.52
4	0.96	0.58
5	0.64	0.35
6	0.97	0.63
7	0.21	0.67
8	1.41	0.67
9	0.96	0.62
10	0.65	0.65
11	1.14	1.13
12	0.55	1.00
13	1.05	0.98
14	2.03	0.95
15s	1.09	0.77
Mean	**0.96**	**0.69**
Range	**0.21-2.03**	**0.26-1.13**

4.2.6 Chromium

The data (Table 23) indicated that the chromium concentration in different soil samples ranged from 0.38 to 0.98 mg kg^{-1} with a mean value of 0.69 mg kg^{-1} and 0.61 to 1.13 mg kg^{-1} with an average value of 0.83 mg kg^{-1} in pre and post-monsoon seasons, respectively. Delbari*et al.*, (2011) observed the similar ranged of chromium concentration in soil. According to Indian Standard Institute, (1996) the maximum permissible limit of chromium for soil is 100 ppm,henceall soil samples contain chromium concentration below the maximum permissible limit in pre and post-monsoon seasons.

In post-monsoon season,the chromium concentration increased in soil due to continuous discharging of industrial waste of manufacture of steel, machine tools and chemical industries (Jerome *et al.*, 2010). Prasad *et al.*, (2007) also reported the similar trends of increased chromium concentration in soil during post-monsoon season due to effect of sugar factory effluent in Wardha district, Maharashtra, India.

Table 23. Variation on chromium concentration (mg kg^{-1}) in soil at pre and post-monsoon season

Available chromium		
Sample No.	**Pre-Monsoon**	**Post- Monsoon**
1	0.38	0.62
2	0.50	0.80
3	0.48	0.71
4	0.98	0.85
5	0.57	0.64
6	0.69	0.68
7	0.53	0.61
8	0.77	0.74
9	0.74	0.82
10	0.61	0.81
11	0.79	1.07
12	0.49	1.13
13	0.92	1.07
14	0.91	0.99
15	0.81	0.95
Mean	**0.69**	**0.83**
Range	**0.38-0.98**	**0.61-1.13**

4.2.7 Cobalt

The perusal of the data presented in Table 24 revealed that the cobalt concentration in soil during pre-monsoon varied from 0.15 to 1.20 mg kg^{-1} with a mean value of 0.56 mg kg^{-1} while for post-monsoon season it was 0.24 to 2.40 mg kg^{-1} with an average value of 1.10 mg kg^{-1}. The maximum permissible limit of cobalt concentration in soil is 50 ppm (ISI, 1996). In present study, all samples contain cobalt concentration below the permissible limit in both pre and post-monsoon season.

In post-monsoon season, it was observed higher, while in pre-monsoon season it showed minimum. The similar results of increased cobalt concentration in soil during post-monsoon season in Kurkumbh industrial area, Pune district, Maharashtra, India have also been reported by Sonavane*et al.*, (2009)

Table 24. Variation oncobalt concentration (mg kg^{-1}) in soil at pre and post-monsoon season

Available cobalt		
Sample No.	**Pre- Monsoon**	**Post- Monsoon**
1	0.22	0.24
2	0.40	0.80
3	0.29	0.58
4	0.28	0.57
5	0.15	0.30
6	1.01	2.02
7	0.93	1.85
8	0.99	1.97
9	1.20	2.40
10	0.92	1.84
11	0.46	0.92
12	0.32	0.64
13	0.42	0.85
14	0.41	0.83
15	0.38	0.77
Mean	**0.56**	**1.10**
Range	**0.15-1.20**	**0.24-2.40**

4.2.8 Lead

As seen from Table 25, the lead concentration in pre and post-monsoon ranged from 0.45 to 3.96 mg kg^{-1} and 1.00 to 2.37 mg kg^{-1} with a mean value of 1.73 and 1.61 mg kg^{-1}, respectively. The results were supported by findings of Patel *et al.*, (2015) for surface soil around Vapi industrial area, Gujarat, India. Indian Standard Institute, (1996) indicated that the maximum permissible limit for lead in soil is 100 ppm, hence the observed lead concentration in all soil samples were below the maximum permissible limit in both season.

The lead concentration decreased in post-monsoon season. The similar trends were observed the concentration of lead in soil of sugar factory effluent in Wardha district, Maharashtra by Joshi *et al.*, (2007).

Table 25. Variation on lead concentration (mg kg^{-1}) in soil at pre and post-monsoon season

Available lead		
Sample No.	**Pre-Monsoon**	**Post-Monsoon**
1	1.25	1.27
2	1.15	2.90
3	0.45	2.37
4	0.83	2.14
5	1.02	1.15
6	1.74	1.43
7	0.95	1.36
8	1.61	1.53
9	1.90	2.06
10	2.69	1.59
11	2.03	1.36
12	1.02	1.31
13	2.54	1.70
14	3.96	1.05
15	2.82	1.00
Mean	**1.73**	**1.61**
Range	**0.45-3.96**	**1.00-3.90**

4.3 Physico-chemical parameters of ground water

4.3.1 pH

The data shown in Table 26, indicated that the pH of water at various months ranges from 5.04 to 6.50, 4.67 to 5.74, 5.01 to 5.61, 6.08 to 6.84, 5.45 to 6.46, 5.12 to 6.84, 5.22 to 6.02, 5.21 to 6.30, 5.25 to 6.04, 4.97 to 5.67, 5.88 to 8.97, 5.01 to 5.86, 5.31 to 6.46, 5.50 to 6.50, 6.26 to 6.99, 5.52 to 6.92, 4.92 to 5.68, 5.60 to 6.69, 5.34 to 6.93 and 5.24 to 6.34 on well No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20, respectively.

The acceptable range of pH for drinking and irrigation purpose is 6.5-8.5 and 6.0-8.5, respectively (BIS, 1991; ALPHA, 1996). In the present investigation most of well water samples were not within acceptable range. However, laterite soil is acidic in nature and hence ground water is also acidic nature.

The pH of water at different seasons varied from 5.25 to 8.97, 4.67 to 8.40 and 4.90 to 6.98 with a mean value of 6.08, 5.77 and 5.89 in summer, monsoon and winter seasons, respectively.

In that area during monsoon season certain chemical and metals are percolating through rain water and accumulated in ground water, hence water had low pH value (Walakira, 2011) and it could be due to discharge industrial effluents, which are acidic and mix in the well water (Sunil *et al.*, 2011).

The higher and lower pH of water observed during summer and monsoon season, respectively. Yadav*et al.*, (2014) observed the similar variation in ground water on Kota district, Rajasthan, India.

4.3.2 Electrical Conductivity

The data presented in Table 27, indicated that the electrical conductivity of water at different months throughout the year on well No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 ranged from 0.130 to 0.389, 0.024 to 0.140, 0.028 to 0.054, 0.371 to 1.196, 0.091 to 0.173, 0.120 to 0.301, 0.030 to 0.135, 0.036 to 0.122, 0.033 to 0.200, 0.036 to 0.116, 0.074 to 0.309, 0.032 to 0.104, 0.031 to 0.071, 0.033 to 0.109, 0.031 to 0.511, 0.122 to 0.551, 0.076

Table 26. Variation of ground water pH at various months from Lore MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	5.71	5.87	5.75	5.04	5.96	5.10	5.34	5.39	5.05	5.16	6.50	5.96
2	5.33	5.74	5.43	4.67	5.48	5.08	5.19	5.42	5.54	4.90	5.41	5.45
3	5.40	5.61	5.31	5.39	5.30	5.30	5.01	5.16	5.26	5.01	5.30	5.32
4	6.18	6.58	6.40	6.08	6.79	6.81	6.79	6.78	6.84	6.08	6.35	6.68
5	6.01	6.46	5.96	5.67	5.92	5.82	5.53	6.25	6.31	5.45	5.85	5.98
6	5.54	5.92	5.68	5.63	6.52	5.76	5.20	6.03	6.84	5.12	5.70	5.78
7	5.56	5.72	5.87	5.22	6.02	5.40	5.29	5.63	5.96	5.50	5.84	6.01
8	5.87	5.89	6.30	5.36	5.80	5.21	5.30	5.71	5.98	5.42	5.45	5.64
9	5.25	6.04	5.78	5.54	5.62	5.47	5.59	5.79	5.84	5.25	5.68	5.89
10	5.65	5.67	5.62	5.28	5.58	5.41	5.24	5.75	5.94	4.97	5.50	5.78
11	8.97	8.32	8.40	5.92	5.93	5.88	5.89	6.91	6.98	6.12	6.65	6.95
12	5.66	5.62	5.76	5.01	5.70	5.38	5.63	5.78	5.64	5.10	5.56	5.86
13	6.46	5.71	5.88	5.60	5.67	5.47	5.50	6.23	6.02	5.31	5.55	5.64
14	6.30	6.25	6.01	5.50	5.91	5.89	5.91	5.96	6.04	6.50	5.64	5.91
15	6.71	6.99	6.54	6.33	6.68	6.26	6.63	6.64	6.78	6.45	6.48	6.52
16	6.92	6.69	6.58	6.04	6.10	6.10	5.52	6.59	6.89	6.48	6.66	6.78
17	5.45	5.31	5.68	4.92	5.40	5.42	5.18	5.35	5.64	5.13	5.47	5.67
18	6.45	6.61	6.69	5.60	6.30	6.04	6.24	6.10	6.34	5.98	6.21	6.20
19	5.89	5.63	5.98	5.34	6.25	6.40	6.63	6.68	6.93	5.78	6.46	6.88
20	5.91	6.34	5.67	5.89	5.81	5.24	5.62	5.29	5.61	5.44	5.52	5.81
Mean	**6.06**	**6.15**	**6.06**	**5.50**	**5.94**	**5.67**	**5.66**	**5.97**	**6.12**	**5.56**	**5.89**	**6.04**
Range	**5.25-8.97**	**5.31-8.32**	**5.31-8.40**	**4.67-6.33**	**5.30-6.79**	**5.08-6.81**	**5.01-6.79**	**5.16-6.91**	**5.05-6.98**	**4.90-6.50**	**5.30-6.66**	**5.32-6.95**

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Table 27. Variation in electrical conductivity (dSm^{-1}) of ground water at various months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	0.389	0.384	0.385	0.346	0.386	0.302	0.201	0.424	0.256	0.268	0.13	0.131
2	0.024	0.032	0.034	0.037	0.14	0.055	0.054	0.055	0.054	0.052	0.049	0.048
3	0.039	0.034	0.04	0.045	0.054	0.043	0.043	0.047	0.041	0.036	0.036	0.028
4	0.351	0.349	0.371	1.196	0.743	0.429	0.431	0.733	0.746	0.758	0.781	0.792
5	0.135	0.173	0.138	0.132	0.165	0.091	0.142	0.119	0.128	0.143	0.113	0.142
6	0.147	0.131	0.209	0.301	0.184	0.127	0.127	0.262	0.12	0.124	0.127	0.146
7	0.076	0.034	0.03	0.079	0.135	0.032	0.039	0.033	0.064	0.084	0.08	0.089
8	0.038	0.036	0.036	0.071	0.122	0.116	0.073	0.074	0.072	0.061	0.056	0.051
9	0.033	0.033	0.034	0.176	0.200	0.119	0.128	0.132	0.121	0.097	0.078	0.082
10	0.072	0.055	0.069	0.036	0.116	0.105	0.079	0.074	0.069	0.061	0.056	0.059
11	0.138	0.309	0.304	0.074	0.123	0.11	0.115	0.167	0.184	0.208	0.118	0.201
12	0.032	0.072	0.053	0.054	0.104	0.051	0.09	0.054	0.05	0.047	0.051	0.068
13	0.034	0.071	0.07	0.031	0.034	0.055	0.033	0.036	0.059	0.065	0.058	0.059
14	0.077	0.033	0.035	0.109	0.036	0.057	0.049	0.037	0.057	0.062	0.057	0.069
15	0.031	0.038	0.039	0.037	0.511	0.221	0.322	0.378	0.392	0.402	0.351	0.389
16	0.122	0.336	0.331	0.34	0.337	0.331	0.537	0.551	0.549	0.551	0.539	0.546
17	0.325	0.315	0.337	0.334	0.129	0.076	0.106	0.208	0.202	0.184	0.191	0.231
18	0.374	0.361	0.365	0.389	0.417	0.274	0.313	0.418	0.439	0.457	0.235	0.356
19	0.018	0.022	0.046	0.053	0.057	0.047	0.053	0.059	0.089	0.104	0.132	0.117
20	0.025	0.033	0.072	0.053	0.038	0.056	0.058	0.053	0.086	0.046	0.046	0.059
Mean	**0.124**	**0.143**	**0.150**	**0.195**	**0.202**	**0.135**	**0.150**	**0.196**	**0.189**	**0.191**	**0.164**	**0.183**
Range	**0.018-0.389**	**0.022-0.384**	**0.030-0.385**	**0.031-1.196**	**0.034-0.743**	**0.032-0.429**	**0.033-0.537**	**0.033-0.733**	**0.041-0.746**	**0.036-0.758**	**0.036-0.781**	**0.028-0.792**

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to 0.337, 0.235 to 0.457, 0.018 to 0.132 and 0.025 to 0.086 dSm^{-1}, respectively.

According to the United State Salinity Laboratory Staff, (1969) the electrical conductivity of water below 0.25 and 0.25 to 0.75 dSm^{-1} are excellent and good water for irrigation purpose, hence all the samples collected from were belonging these categories throughout year.

The electrical conductivity of water were varied from 0.018 to 0.792 dSm^{-1} with a mean value of 0.150, 0.030 to 1.196 dSm^{-1} with an average value of 0.166 dSm^{-1} and 0.033 to 0.781 dSm^{-1} with a mean value of 0.185 dSm^{-1} during summer, monsoon and winter seasons, respectively. The electrical conductivity increased during monsoon and winter season due to increase in number of ions which is supported bysalinity value (Ramesh *et al.*, 2014) and lower during summer due to increased rate of precipitation (Kataria*et al.*, 1994).The similar results of higher conductivity of water during monsoon and winter season due to effect of industrial effluent in water on Karnataka, India have been reported by Srikantaswamy*et al.*, (2013). Hussain*et al.*, (2013) also found a similar result due effect of industrial waste on electrical conductivity of water in Tamil Nadu, India.

4.3.3 Bicarbonates

The perusal of data presented in Table 28 revealed that bicarbonate concentration during different months in well water No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 varied from 24.4 to 109.80, 24.40 to 73.21, 24.40 to 85.41, 85.41 to 195.20, 36.61 to 170.83, 36.61to 85.41, 36.61 to 134.22, 24.40 to 109.82, 48.82 to 97.60, 36.61 to 146.42, 36.61 to 134.22, 36.61 to 170.83, 48.82 to 109.80, 24.40 to 85.41, 48.82 to 158.40, 85.41 to 158.60, 36.61 to 85.41, 48.82 to 170.83, 24.40 to 73.21 and 36.61 to 158.63 mg L^{-1}, respectively.

The desirable and maximum permissible limit of bicarbonate concentration in ground water is 200 and 600 mg L^{-1} for drinking

Table 28. Variation in bicarbonate concentration (mgL^{-1}) of ground water at various months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	73.21	73.21	85.41	85.41	61.01	24.40	36.61	73.21	73.21	109.80	85.41	109.82
2	61.01	48.82	48.82	24.40	48.82	48.82	36.61	36.61	48.82	48.82	61.01	73.21
3	61.01	85.41	73.21	24.40	36.61	36.61	48.82	48.82	48.82	61.01	73.21	73.21
4	85.41	146.42	134.20	85.41	134.20	158.40	195.20	146.40	158.40	134.20	146.42	158.63
5	73.21	61.01	48.82	36.61	61.01	73.21	61.01	61.01	85.41	73.21	109.82	170.83
6	61.01	73.21	48.82	48.82	85.41	73.21	48.82	36.61	61.01	85.41	48.82	73.21
7	85.41	48.82	61.01	36.61	73.21	36.61	61.01	36.61	61.01	48.82	97.62	134.22
8	48.82	109.82	73.21	24.40	36.61	48.82	73.21	73.21	97.62	61.01	85.41	109.82
9	48.82	85.41	61.01	48.82	61.01	97.60	73.21	61.01	73.21	73.21	73.21	73.21
10	48.82	48.82	97.62	36.61	48.82	61.01	61.01	48.82	48.82	48.82	97.62	146.42
11	73.21	134.22	109.82	48.82	36.61	61.01	48.82	97.62	97.62	97.62	85.41	97.62
12	170.83	73.21	73.21	48.82	61.01	36.61	36.61	61.01	61.01	73.21	73.21	85.21
13	85.41	48.82	61.01	48.82	48.82	48.82	48.82	85.41	109.80	73.21	48.82	48.82
14	36.61	73.21	85.41	61.01	48.82	24.40	48.82	36.61	36.61	61.01	61.01	61.01
15	73.21	48.82	146.40	134.22	146.40	158.40	158.40	146.40	109.82	134.20	146.42	142.42
16	134.22	134.22	158.60	109.80	85.41	146.40	97.62	109.82	146.40	109.82	134.22	134.22
17	48.82	73.21	73.21	36.61	48.82	85.41	48.82	61.01	85.41	48.82	48.82	48.82
18	73.21	109.82	97.62	48.82	73.21	170.83	85.41	85.41	109.80	122.02	158.63	73.21
19	48.82	48.82	73.21	36.61	24.40	24.40	48.82	61.01	85.41	48.82	61.01	61.01
20	36.61	97.62	48.82	48.82	48.82	73.21	61.01	48.82	85.41	61.01	97.62	158.63
Mean	**71.38**	**81.15**	**82.97**	**53.69**	**63.45**	**74.41**	**68.93**	**70.77**	**84.18**	**78.70**	**89.69**	**101.68**
Range	**36.61-170.83**	**48.82-146.42**	**48.82-158.60**	**24.40-134.22**	**24.40-146.40**	**24.40-170.83**	**36.61-195.20**	**36.61-146.40**	**36.61-158.40**	**48.82-134.20**	**48.82-158.63**	**48.82-170.83**

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purpose, respectively (BIS, 1990). The data showed that bicarbonate concentration in all water samples is below the maximum permissible limit.

The bicarbonate concentration in water during summer season varied from 31.61 to 170.83 mg L^{-1} with an average value of 84.74 mg L^{-1},while during monsoon season ranged from 24.20 to 195.20 mg L^{-1} and its mean value of 68.69 mg L^{-1}. In winter season varied from 31.61 to 158.63 mg L^{-1} with a mean value of 80.84 mg L^{-1}.

The concentration of bicarbonate is lower during monsoon season due to dilution effect of rain water (Prasath*et al.*, 2013). The similar results of lower bicarbonate concentration in water on Bidadi industrial area, Karnataka, India have been observed by Madhukar*et al.*, (2013). Gupta *et al.*, (2014) also found similar results of ground water in Kota, Rajasthan.

4.3.4 Chlorides

Chlorides are found in ground water through natural and anthropogenic sources, such as weathering of rocks and leaching of inorganic fertilizers, dumps or landfills, industrial effluents etc. (Yadav*et al.*, 2014).

The data related to chloride concentration presented in Table 29 various samples No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 contain chloride concentration of ground water ranged from 156.02 to 241.13, 113.47 to 226.94, 113.47 to 198.58, 212.76 to 482.26, 127.66 to 226.94, 170.21 to 269.50, 99.29 to 226.94, 127.66 to 198.58, 127.66 to 198.58, 127.66 to 269.50, 141.84 to 212.76, 127.57 to 212.76, 113.47 to 297.86, 127.66 to 226.94, 184.39 to 340.42, 212.76 to 354.60, 184.39 to 269.50, 226.94 to 482.26, 141.84 to 241.13 and 127.66 to 212.76 mg L^{-1}, respectively.

The desirable and maximum permissible limit of chloride concentration is 250 and 1000 mg L^{-1}, respectively for drinking and irrigation purpose (BIS, 1990; WHO, 1984). In experimental data the

Table 29. Variation in chloride concentration (mg L^{-1}) of ground water at various months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	198.58	241.13	212.76	170.21	198.58	170.21	170.21	170.21	184.39	241.13	156.02	170.21
2	184.39	113.47	127.66	141.84	184.39	212.76	198.58	212.76	212.76	226.94	198.58	198.58
3	127.66	198.58	184.39	113.47	127.66	141.84	156.02	184.39	170.21	170.21	156.02	141.84
4	326.23	297.86	326.23	482.26	269.50	212.76	226.94	312.02	297.86	269.50	312.05	297.86
5	184.39	198.58	226.94	127.66	212.76	170.21	198.58	184.39	184.39	198.58	184.39	184.39
6	170.21	226.94	198.58	170.21	269.50	184.39	184.39	184.39	198.58	212.76	184.39	170.21
7	184.39	127.66	170.21	99.29	184.39	212.76	198.58	156.02	184.39	226.94	170.21	184.39
8	184.39	184.39	170.21	127.66	141.84	198.58	184.39	198.58	198.58	170.21	156.02	156.02
9	170.21	198.58	156.02	170.21	127.66	184.39	184.39	184.58	170.21	170.21	156.02	141.84
10	198.58	269.50	255.31	127.66	141.84	212.76	184.39	212.76	198.58	156.02	170.21	156.02
11	198.58	184.39	212.76	141.84	156.02	156.02	170.21	141.84	156.02	184.39	198.58	184.39
12	170.21	156.02	156.02	127.57	170.21	170.21	184.39	184.39	184.39	198.58	212.76	198.58
13	170.21	170.21	184.39	113.47	156.02	156.02	170.21	297.86	269.50	170.21	184.39	184.39
14	170.21	156.02	198.58	127.66	141.84	141.84	184.39	198.58	198.58	226.94	198.58	198.58
15	184.39	198.58	198.58	212.76	198.58	269.50	198.58	340.42	269.50	226.94	198.58	184.39
16	226.94	241.13	212.76	354.60	312.05	226.94	326.23	354.60	297.86	297.86	297.86	269.50
17	198.58	241.13	241.13	226.94	184.39	269.50	241.13	212.76	226.94	226.94	184.39	184.39
18	340.42	368.78	382.97	368.78	482.26	269.50	255.31	241.13	226.94	312.05	269.50	269.50
19	226.64	212.76	241.13	198.58	156.02	184.39	184.39	198.58	198.58	198.58	156.02	141.84
20	198.58	184.39	184.39	184.39	170.21	127.66	156.02	156.02	170.21	212.76	170.21	198.58
Mean	**200.69**	**208.50**	**212.05**	**189.35**	**199.29**	**193.61**	**197.87**	**216.31**	**209.92**	**214.89**	**195.74**	**190.77**
Range	**127.6-340.42**	**113.47-368.78**	**127.66-382.97**	**99.29-482.26**	**127.66-482.26**	**127.66-269.50**	**156.0-326.23**	**141.8-354.60**	**156.0-297.86**	**156.02-312.05**	**156.0-312.05**	**141.8-297.86**

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ground water samples showed chloride concentration below the maximum permissible limit.

The seasonal variation of chloride concentration in ground water during summer, monsoon and winter season varied from 113.47 to 297.86, 99.29 to 482.26 and 141.84 to 354.60 mg L^{-1} with an average value of 199.99, 198.43 and 209.22 mg L^{-1}, respectively.

The chloride concentration is lower in monsoon season as compared to summer and winter season might due to evaporation, dilution effect and anthropogenic influences as chloride readily transported through soil (Rao*et al.*, 2013). Since a lesser amount of concentrationchloride could be added by natural resources and higher is indicative of industrial pollution (Thomas *et al.*, 2011).The similar seasonal variation of chloride concentration in water has been reported by Singh *et al.*, (2014).

4.3.5 Sodium

Sodium is highly soluble chemical element, which is naturally found in ground water. The data presented in Table 30 related to sodium concentration of ground water varied from 3.20 to 32.40, 2.20 to 11.40, 2.40 to 13.80, 23.40 to 202.00, 4.70 to 12.60, 6.00 to 11.70, 4.60 to 10.50, 4.80 to 12.90, 5.10 to 10.80, 3.10 to 10.60, 2.20 to 13.40, 2.50 to 14.90, 2.30 to 11.00, 4.50 to 12.90, 12.30 to 21.10, 7.80 to 15.40, 3.60 to 22.10, 13.20 to 30.50, 3.30 to 12.20 and 2.10 to 16.70 ppm on various month in different samples No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20, respectively.

The maximum allowable limit of sodium in drinking water is 200 mg L^{-1} (WHO, 1984). In present study, all the water samples contain sodium concentration below the maximum permissible limit.

The sodium concentration of ground water was in the range from 3.10 to 202.00, 2.10 to 68.90 and 2.90 to 78.60 ppm with a mean value of 18.53, 9.34 and 11.81 ppm during summer, monsoon and winter season, respectively.

The concentration of sodium in ground water is lower during monsoon season and higher in summer season due to dilution effect.

Table 30. Variation in sodium concentration (ppm) of ground water at various months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	11.20	32.40	23.60	16.20	6.60	3.20	4.20	5.20	5.70	6.70	6.50	6.30
2	11.30	11.40	4.50	2.60	2.20	2.60	4.60	6.80	6.90	4.90	4.70	4.50
3	10.80	13.80	7.60	2.60	2.40	2.50	4.20	7.40	6.10	5.20	2.90	3.10
4	163.00	202.00	63.20	68.90	36.70	26.40	23.40	57.10	61.70	78.60	77.80	75.10
5	10.90	12.60	10.40	8.60	6.30	4.70	6.10	8.00	8.70	9.20	7.80	7.10
6	11.00	11.70	11.50	7.60	6.00	6.00	7.10	7.70	8.10	9.00	7.30	6.30
7	10.50	10.50	6.20	4.60	4.70	4.70	6.60	8.10	8.20	4.70	5.80	5.20
8	11.20	12.90	7.10	10.60	8.40	4.80	11.80	12.70	11.30	6.00	9.70	9.90
9	10.80	10.50	9.60	6.50	6.50	5.40	7.00	8.20	7.80	5.80	5.10	5.10
10	10.50	10.60	8.60	3.90	4.20	3.10	6.40	6.70	6.20	4.40	4.00	4.20
11	13.40	10.80	9.20	5.40	2.30	2.20	4.90	6.90	6.30	5.80	3.60	3.30
12	12.70	14.90	10.30	3.60	2.80	2.50	5.30	6.00	5.60	3.50	3.50	5.90
13	10.70	11.00	3.80	3.00	2.40	2.30	5.20	6.80	6.40	4.50	3.10	3.70
14	10.60	10.70	9.60	5.00	5.10	4.50	6.50	8.20	7.90	6.00	12.80	12.90
15	14.20	14.10	15.90	14.70	19.00	19.30	16.90	21.10	18.20	15.20	13.10	12.30
16	12.50	13.20	13.40	12.60	8.10	7.80	11.50	14.20	14.40	15.40	11.90	11.40
17	21.80	21.70	22.10	18.10	5.90	3.60	7.80	14.40	15.20	14.80	15.50	15.90
18	30.50	27.50	24.40	16.40	14.60	13.20	14.00	18.70	18.90	19.70	19.90	21.50
19	12.00	12.20	10.40	3.90	3.90	3.30	6.50	9.40	9.70	9.60	9.50	9.70
20	11.20	11.10	4.60	3.10	2.60	2.10	5.10	5.90	5.20	3.00	10.50	16.70
Mean	**20.54**	**23.78**	**13.80**	**10.90**	**7.54**	**6.21**	**8.26**	**11.98**	**11.93**	**11.60**	**11.75**	**12.01**
Range	**10.50-163.00**	**10.50-202.00**	**3.80-63.20**	**2.60-68.90**	**2.20-36.70**	**2.10-26.40**	**4.20-23.40**	**5.20-57.10**	**5.20-61.70**	**3.00-78.60**	**2.90-77.80**	**3.10-75.10**

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During summer season maximum sodium concentration in ground water due to low water level and high evaporation losses (Yadav*et al.*, 2014).

The similar results of higher concentration of sodium in ground water on pre-monsoon season due to effect of factory waste on Tamil Nadu, India have been reported by Rao*et al.*, (2013).

4.3.6 Calcium

The data (Table 31) indicated that the calcium concentration in ground water ranged from 8.02 to 36.72, 12.02 to 44.09, 8.02 to 48.10, 48.10 to 100.20, 12.02 to 48.10, 12.02 to 44.09, 12.02 to 64.13, 8.02 to 48.08, 8.02 to 48.10, 8.02 to 40.08, 12.02 to 44.09, 8.02 to 32.07, 12.02 to 24.02, 12.02 to 56.11, 36.07 to 96.19, 40.08 to 84.17, 8.02 to 24.05, 20.04 to 124.25, 12.02 to 48.08 and 8.02 to44.09 mg L^{-1} on various well No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20, respectively in different months.

The data showed that ground water samples were below the maximum permissible limit of calcium concentration in ground water as drinking purpose (BIS, 1990; WHO, 1984).

The calcium concentration in ground water ranged from 12.02 to 124.25, 8.02 to 112.22 and 8.02 to 84.17 mg L^{-1} with a mean value of 37.77, 30.70 and 26.15 mg L^{-1} during summer, monsoon and winter season, respectively.

The calcium concentration is higher in ground water during summer season as compared to monsoon and winter seasons, there was continuous decreased during winter season. During summer season, higher calcium concentration in ground water was observed due to industries pollution, low water level and high evaporation (Deshmukh, 2014). The similar results of seasonal variation of calcium concentration in ground water of Punjab, India have been found by Kaur*et al.*, (2014).

4.3.7 Magnesium

The data (Table 32) related to well No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 contain magnesium

Table 31. Variation in calcium concentration (mgL^{-1}) of ground water at various months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	36.72	32.07	32.07	28.06	24.05	12.02	8.02	16.03	20.04	20.04	16.03	24.04
2	28.06	24.05	40.08	44.09	12.02	12.02	12.02	12.02	12.02	16.03	12.02	20.04
3	48.10	16.03	24.05	24.05	12.02	16.03	8.02	12.02	20.04	20.04	28.06	36.07
4	48.10	52.10	68.14	68.14	100.20	76.15	48.10	64.13	68.14	76.15	52.10	60.12
5	48.10	40.08	24.05	32.06	20.04	16.03	12.02	16.03	16.03	16.03	12.02	24.05
6	44.09	36.07	32.07	36.07	24.05	20.04	12.02	12.02	20.04	24.05	12.02	16.03
7	25.10	52.10	64.13	44.09	16.03	12.02	12.02	16.03	12.02	12.02	16.03	24.05
8	48.08	16.03	16.03	44.09	12.02	16.03	8.02	12.02	24.05	36.07	24.05	28.06
9	20.04	24.05	48.10	36.07	28.06	20.04	12.02	16.03	12.02	8.02	8.02	12.02
10	16.03	36.07	40.08	36.06	12.02	16.03	8.02	16.03	16.03	24.05	12.02	16.03
11	24.05	28.05	28.06	28.06	20.04	20.04	12.02	24.05	24.05	24.05	36.07	44.09
12	12.02	28.06	32.07	32.07	16.03	16.03	8.02	16.03	24.05	28.06	12.02	16.03
13	20.04	24.05	24.05	24.05	12.02	12.02	12.02	16.03	16.03	12.02	16.03	16.03
14	48.10	56.11	56.11	36.07	40.08	24.05	12.02	16.03	16.03	20.04	20.04	28.06
15	64.13	64.13	44.09	44.09	88.18	84.17	36.07	72.14	64.13	52.10	84.17	96.19
16	48.10	56.11	52.01	52.10	40.08	52.10	52.10	64.13	56.11	48.10	72.14	84.17
17	24.05	24.05	20.04	20.04	16.03	12.02	8.02	20.04	20.04	24.05	12.02	20.04
18	124.25	84.17	112.22	112.22	52.10	44.09	20.04	48.10	48.10	56.11	52.10	76.15
19	48.08	28.06	44.09	36.07	24.05	16.03	12.02	12.02	12.02	12.02	24.05	32.06
20	44.08	40.08	44.09	40.08	12.02	8.02	8.02	12.02	12.02	16.03	20.04	12.02
Mean	**40.97**	**38.08**	**42.28**	**40.88**	**29.06**	**25.25**	**16.03**	**24.65**	**25.65**	**27.25**	**27.05**	**34.27**
Range	**12.02-124.25**	**16.03-84.17**	**16.03-112.22**	**20.04-112.22**	**12.02-100.20**	**8.02-84.17**	**8.02-52.10**	**12.02-72.14**	**12.02-68.14**	**8.02-76.15**	**8.02-84.17**	**12.02-96.19**

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Table 32. Variation of magnesium concentration (mgL^{-1}) in ground water at various months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	9.73	2.43	4.86	4.86	7.30	4.86	2.43	2.43	4.86	4.86	4.86	7.30
2	0.00	4.86	2.43	4.86	2.43	0.00	0.00	2.43	2.43	2.43	7.30	4.86
3	2.43	4.86	7.30	7.30	7.30	2.43	2.43	4.86	2.43	2.43	4.86	4.86
4	70.53	82.69	58.37	58.37	14.59	17.02	2.43	19.46	12.16	4.86	19.46	19.46
5	9.73	0.00	12.16	7.30	7.30	2.43	4.86	2.43	2.43	0.00	14.59	7.30
6	2.43	2.43	7.30	4.86	12.16	4.86	4.86	7.30	0.00	0.00	7.30	7.30
7	7.30	4.86	2.43	12.16	4.86	4.86	0.00	0.00	2.43	0.00	0.00	2.43
8	2.43	0.00	2.43	0.00	2.43	2.43	2.43	0.00	2.43	0.00	4.86	2.43
9	4.86	4.86	4.86	7.30	7.30	7.30	2.43	4.86	4.86	4.86	12.16	2.43
10	4.86	2.43	4.86	4.86	2.43	0.00	2.43	0.00	0.00	0.00	4.86	4.86
11	9.73	2.43	0.00	0.00	4.86	2.43	2.43	2.43	2.43	7.26	7.30	2.43
12	12.16	9.73	9.73	2.43	2.43	0.00	4.86	2.43	0.00	2.43	2.43	12.16
13	4.86	7.30	12.16	12.16	2.43	0.00	4.86	0.00	0.00	0.00	4.86	4.86
14	9.73	7.30	2.43	4.86	2.43	7.30	2.43	2.43	0.00	4.86	0.00	2.43
15	19.46	19.46	38.91	38.91	7.30	2.43	7.30	7.30	19.46	14.59	7.30	4.86
16	14.59	9.73	19.46	26.75	12.16	14.59	9.73	19.46	17.02	38.91	12.16	2.43
17	36.48	14.59	26.75	19.46	2.43	0.00	2.43	4.86	2.43	0.00	9.73	4.86
18	12.16	7.30	36.48	14.59	9.73	9.73	9.76	7.30	12.16	12.16	4.86	0.00
19	9.73	19.46	4.86	12.16	17.02	4.86	0.00	2.43	0.00	2.43	4.86	2.43
20	9.73	12.16	12.16	12.16	7.30	2.43	7.30	0.00	2.43	2.43	4.86	2.43
Mean	**12.65**	**10.94**	**16.29**	**12.77**	**6.81**	**4.50**	**3.77**	**4.62**	**4.50**	**5.23**	**6.93**	**5.11**
Range	**0.00-70.53**	**0.00-82.69**	**0.00-58.37**	**0.00-58.37**	**2.43-17.02**	**0.00-17.02**	**0.00-9.76**	**0.00-19.46**	**0.00-19.46**	**0.00-38.91**	**0.00-19.46**	**0.00-19.46**

concentration in ground water ranging from 2.43 to 9.73, 0.00 to 7.30, 2.43 to 7.30, 2.43 to 82.69, 0.00 to 14.59, 0.00 to 12.16, 0.00 to 12.16, 0.00 to 4.6, 2.43 to 12.16, 0.00 to 4.86, 0.00 to 9.73, 0.00 to 12.16, 0.00 to 12.16, 0.00 to 9.73, 2.43 to 38.91, 2.43 to 38.91, 0.00 to 68.10, 0.00 to 58.37, 0.00 to 19.46 and 0.00 to 38.91 mg L^{-1}, respectively during various months.

The desirable and maximum permissible limit for magnesium concentration is 30 and 150 mgL^{-1}, respectivelyin drinking water (BIS, 1990; WHO, 1984). In present study,the water samples showed magnesium concentration below the maximum permissible limit in ground water.

The variation of magnesium concentration in ground water varied from 0.00 to 82.69 mg L^{-1} with a mean value of 9.57 mg L^{-1} during summer, 0.00 to 58.37 mg L^{-1} with an average value of 8.27 mg L^{-1} in monsoon and 0.00 to 38.91 mg L^{-1} with an average value of 5.32 mg L^{-1} in winter season, respectively.

During summer season higher magnesium concentration in ground water may be due to polluting industries situated near the water sources, low water level and high evaporation (Deshmukh, 2014). The similar results of seasonal variation of magnesium concentrations in ground water have been found by Yadav*et al.*, (2014).

4.3.8 Sodium Adsorption Ratio

The data presented in Table 33 for sodium adsorption ratio in ground water varied from 0.278 to 1.990, 0.140 to 0.830, 0.140 to 1.095, 1.007 to 5.790, 0.409 to 0.894, 0.352 to 0.759, 0.224 to 0.798, 0.389 to 1.427, 0.340 to 0.793, 0.229 to 0.719, 0.169 to 0.793, 0.233 to 1.094, 0.176 to 0.786, 0.293 to 1.113, 0.469 to 0.948, 0.331 to 0.642, 0.405 to 1.219, 0.442 to 0.959, 0.203 to 1.099 and 0.118 to 1.624 at various months in different samples No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20, respectively.The United State Salinity Laboratory Staff, (1969) proposed Sodium Adsorption Ratio water classes for irrigation purpose (Table 6). The

Sodium Adsorption Ratio of all the ground water samples found to be less than 10, which shown low sodium hazard making it suitable for irrigation in almost all type of soil.

The Seasonal variation in Sodium Adsorption Ratio of ground water from 0.182 to 5.790 with a mean value of 0.883 in summer, while 0.543 was an average value found in monsoon and it ranged between 0.118 to 2.521 and it ranged from 0.188 to 3.334 with a mean value 0.758 during winter season. The similar ranges were also found by Banjare*et al.*, (2010).

The sodium Adsorption Ratio is lower during monsoon season due to less amounts of sodium salts present in ground water (Bhadra*et al.*, 2012). Jain *et al.*, (2012) also observed the similar variation in ground water at Nainital, India.

4.3.9 Residual Sodium Carbonate

The perusal of data presented on Table 34 revealed that the Residual Sodium Carbonate present in ground water was ranging from 0.10 to 1.21, -0.81 to 0.65, -0.27 to 0.85, -0.18 to 2.39, -0.14 to 2.17, 0.05 to 0.85, -0.29 to 1.61, -0.34 to 1.35, 0.03 to 0.89, -0.14 to 1.85, 0.01 to 1.61, 0.13 to 2.17, 0.06 to 1.35, -0.38 to 0.53, -0.30 to 1.83, 0.53 to 1.55, -0.69 to 1.01, -0.81 to 1.93, -0.41 to 1.01 and -0.34 to 2.15 on water sample No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20, respectively in various months.

The United State Salinity Laboratory Staff, (1969) proposed the Residual Sodium Carbonate value for irrigation water (Table 7). During the study, the RSC values (Table 29) clearly indicated that the ground water is not having any residual sodium carbonate hazard.

The Residual Sodium Carbonate value in ground water ranged from -0.71 to 2.17, -0.81 to 2.39 and 0.05 to 1.63 with a mean value of 0.58, 0.42 and 0.70 during summer, monsoon and winter season, respectively. Residual Sodium Carbonate value is lower during monsoon season as compared to summer and winter season in ground water. Jain *et al.*, (2012) also found the similar range of RSC

Table 33. Variation in Sodium Adsorption Ratio of ground water at various months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	0.604	1.990	1.451	1.051	0.428	0.278	0.365	0.452	0.419	0.492	0.576	0.463
2	0.830	0.740	0.264	0.140	0.214	0.292	0.517	0.661	0.671	0.426	0.373	0.357
3	0.633	1.095	0.492	0.140	0.190	0.217	0.472	0.643	0.484	0.381	0.188	0.182
4	4.949	5.790	1.919	1.870	2.521	1.007	1.262	2.267	2.557	3.334	3.300	3.046
5	0.530	0.707	0.609	0.504	0.433	0.409	0.530	0.697	0.757	0.894	0.505	0.488
6	0.617	0.631	0.674	0.445	0.352	0.441	0.617	0.759	0.704	0.714	0.579	0.463
7	0.511	0.527	0.292	0.224	0.373	0.409	0.741	0.738	0.798	0.528	0.564	0.382
8	0.656	1.255	0.617	0.621	0.817	0.417	1.326	1.427	0.830	0.389	0.667	0.720
9	0.793	0.722	0.499	0.365	0.340	0.371	0.681	0.551	0.678	0.564	0.701	0.496
10	0.680	0.652	0.482	0.229	0.409	0.302	0.719	0.652	0.603	0.349	0.348	0.333
11	0.673	0.793	0.676	0.397	0.169	0.175	0.477	0.507	0.463	0.376	0.221	0.185
12	0.874	1.094	0.578	0.233	0.243	0.243	0.516	0.522	0.444	0.241	0.278	0.382
13	0.786	0.757	0.223	0.176	0.233	0.258	0.452	0.661	0.623	0.493	0.246	0.294
14	0.516	0.537	0.397	0.293	0.573	0.357	0.632	0.713	0.768	0.441	1.113	0.888
15	0.564	0.560	0.595	0.550	0.739	0.783	0.948	0.895	0.722	0.678	0.520	0.469
16	0.331	0.642	0.555	0.500	0.407	0.358	0.542	0.564	0.611	0.638	0.483	0.398
17	0.925	1.219	1.219	0.616	0.513	0.405	0.876	1.058	1.206	1.174	1.138	1.168
18	0.694	0.917	0.917	0.442	0.688	0.663	0.820	0.939	0.891	0.879	0.887	0.959
19	0.623	0.559	0.559	0.203	0.210	0.262	0.730	0.914	1.099	0.934	0.634	0.629
20	0.562	0.540	0.540	0.118	0.206	0.236	0.443	0.663	0.506	0.261	1.021	1.624
Mean	**0.868**	**1.086**	**0.678**	**0.456**	**0.503**	**0.394**	**0.683**	**0.814**	**0.792**	**0.709**	**0.717**	**0.696**
Range	**0.331-4.949**	**0.527-5.790**	**0.223-1.919**	**0.118-1.870**	**0.169-2.521**	**0.175-1.007**	**0.365-1.326**	**0.452-2.267**	**0.419-2.557**	**0.241-3.334**	**0.188-3.300**	**0.182-3.046**

Table 34.Variation in Residual Sodium Carbonate of ground water at various months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	0.39	0.49	0.69	0.73	0.33	0.10	0.10	0.70	0.61	0.21	0.85	1.21
2	0.41	0.13	0.06	0.04	0.35	0.41	0.21	0.15	0.35	0.30	0.45	0.65
3	0.26	0.85	0.53	-0.27	0.05	0.10	0.41	0.30	0.25	0.65	0.53	0.46
4	-0.03	0.88	0.77	-0.18	0.96	1.46	2.39	1.31	1.55	1.18	1.38	1.53
5	0.31	0.23	0.06	-0.14	0.37	0.57	0.50	0.50	0.90	0.75	1.13	2.17
6	0.23	0.39	0.06	0.06	0.66	0.46	0.41	0.05	0.50	0.85	0.25	0.61
7	0.51	-0.07	0.08	0.36	0.65	0.05	0.61	0.15	0.55	0.41	1.15	1.61
8	0.06	1.35	0.70	-0.34	0.15	0.35	0.81	0.81	1.01	0.33	0.77	1.21
9	0.21	0.77	0.16	0.03	0.29	0.89	0.75	0.45	0.70	0.75	0.88	0.75
10	0.13	0.09	0.83	-0.14	0.35	0.55	0.61	0.35	0.35	0.25	1.10	1.85
11	0.33	1.61	1.21	0.21	0.01	0.45	0.35	1.01	1.01	0.93	0.69	0.83
12	2.17	0.61	0.43	0.13	0.50	0.15	0.15	0.50	0.45	0.57	0.65	0.73
13	0.81	0.17	0.26	0.06	0.35	0.41	0.30	0.95	1.35	0.81	0.25	0.25
14	-0.38	0.33	0.53	0.26	0.45	-0.15	0.35	0.10	0.15	0.41	0.50	0.37
15	0.11	-0.30	1.24	1.04	1.28	1.53	1.83	1.38	0.70	1.23	1.31	1.19
16	0.56	1.31	1.55	0.71	0.53	1.45	0.68	0.71	1.38	0.75	1.13	0.96
17	-0.23	0.43	0.31	0.12	0.30	1.01	0.41	0.41	0.85	0.25	0.21	0.21
18	-0.71	0.77	0.13	-0.81	0.28	1.93	0.66	0.53	0.88	1.03	1.63	0.23
19	-0.04	-0.15	0.39	-0.24	-0.41	-0.15	0.41	0.55	1.01	0.35	0.37	0.33
20	-0.27	0.71	-0.09	-0.34	0.25	0.81	0.50	0.41	0.95	0.50	1.15	2.15
Mean	**0.240**	**0.530**	**0.494**	**0.063**	**0.386**	**0.621**	**0.624**	**0.567**	**0.776**	**0.626**	**0.819**	**0.964**
Range	**-0.71-2.17**	**-0.30-1.61**	**-0.09-1.55**	**-0.81-1.04**	**-0.41-1.28**	**-0.15-1.93**	**0.10-2.39**	**0.05-1.38**	**0.15-1.55**	**0.21-1.23**	**0.21-1.63**	**0.21-2.17**

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value in ground water of Nainital, Uttarakhand, India.

4.4 Heavy metal concentrations in ground water

4.4.1 Iron

The perusal of data presented in Table 35 indicated that the concentration of iron in ground water ranged from 0.033 to 0.098, 0.027 to 0.107, 0.028 to 0.104, 0.032 to 0.098, 0.029 to 0.117, 0.053 to 0.104, 0.042 to 0.103, 0.035 to 0.093, 0.025 to 0.117, 0.035 to 0.124, 0.061 to 0.113, 0.037 to 0.114, 0.032 to 0.109, 0.059 to 0.109, 0.079 to 0.108, 0.057 to 0.106, 0.066 to 0.108, 0.044 to 0.109, 0.051 to 0.098 and 0.063 to 0.102 mg L-1 on various well No. 1, 2, 3, 4, 5, 6,7, 8, 9, 10, 11, 12, 13, 14, 14, 15, 16, 17, 18, 19 and 20, respectively during different months throughout year.

According to BIS, (1991) the desirable and maximum permissible limit of Iron for drinking water is 0.3 and 1.0 mg L^{-1}, respectively. Environmental Study Board, (1973) indicated the tolerance limit is 5.0 mg L^{-1} iron in water for irrigation purpose. In present data shown all water samples below the maximum permissible limit of iron concentration in ground water and it is safe for both drinking and irrigation purposes.

The iron concentration in ground water varied from 0.010 to 0.117, 0.027 to 0.124 and 0.010 to 0.111 mg L^{-1} with a mean value of 0.073, 0.075 and 0.076 mg L^{-1} during summer, monsoon and winter season, respectively.

In monsoon and winter higher concentration of iron in ground water was observed due to leaching of industrial wastes during rainy season and natural presence of iron oxides in laterite soil (Thomas *et al.* 2011). Latha*et al.*, (2011) were observed the similar results for seasonal variation in iron of ground water.

4.4.2 Zinc

The data presented in Table 36 revealed that zinc concentration in well No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 contain at various months varied from 0.050 to 0.076,

Table 35. Variation of iron concentration (mgL^{-1}) in ground water at different months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	0.098	0.033	0.068	0.071	0.071	0.075	0.085	0.091	0.087	0.089	0.081	0.086
2	0.107	0.057	0.027	0.052	0.059	0.06	0.067	0.039	0.065	0.081	0.084	0.079
3	0.104	0.064	0.028	0.052	0.099	0.063	0.052	0.033	0.049	0.062	0.062	0.061
4	0.098	0.052	0.037	0.064	0.061	0.068	0.086	0.042	0.039	0.032	0.035	0.032
5	0.071	0.029	0.115	0.072	0.071	0.069	0.071	0.073	0.089	0.094	0.102	0.117
6	0.063	0.053	0.104	0.086	0.078	0.068	0.073	0.077	0.079	0.082	0.089	0.099
7	0.055	0.042	0.103	0.065	0.069	0.074	0.067	0.045	0.066	0.094	0.101	0.099
8	0.079	0.035	0.093	0.058	0.059	0.046	0.041	0.049	0.058	0.065	0.069	0.071
9	0.025	0.035	0.117	0.058	0.061	0.065	0.072	0.096	0.099	0.104	0.101	0.105
10	0.036	0.035	0.124	0.089	0.081	0.081	0.088	0.098	0.109	0.099	0.109	0.115
11	0.105	0.113	0.102	0.088	0.079	0.062	0.061	0.065	0.067	0.061	0.069	0.071
12	0.039	0.048	0.037	0.087	0.081	0.078	0.079	0.100	0.107	0.101	0.111	0.114
13	0.032	0.046	0.109	0.088	0.089	0.089	0.073	0.065	0.061	0.064	0.066	0.069
14	0.109	0.087	0.106	0.067	0.066	0.067	0.062	0.061	0.059	0.063	0.061	0.065
15	0.102	0.103	0.108	0.083	0.086	0.079	0.088	0.106	0.089	0.081	0.086	0.089
16	0.101	0.106	0.101	0.085	0.089	0.057	0.064	0.098	0.096	0.097	0.099	0.093
17	0.089	0.091	0.108	0.077	0.071	0.068	0.066	0.074	0.079	0.078	0.081	0.077
18	0.074	0.056	0.044	0.090	0.089	0.088	0.083	0.079	0.077	0.071	0.099	0.109
19	0.051	0.052	0.056	0.098	0.077	0.065	0.061	0.066	0.071	0.069	0.074	0.077
20	0.102	0.099	0.101	0.081	0.071	0.065	0.063	0.071	0.081	0.075	0.099	0.087
Mean	**0.077**	**0.057**	**0.084**	**0.076**	**0.075**	**0.069**	**0.070**	**0.071**	**0.076**	**0.078**	**0.079**	**0.086**
Range	**0.025-0.109**	**0.029-0.113**	**0.027-0.124**	**0.052-0.098**	**0.059-0.099**	**0.046-0.089**	**0.041-0.088**	**0.033-0.106**	**0.039-0.109**	**0.032-0.104**	**0.035-0.111**	**0.032-0.117**

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0.041 to 0.089, 0.026 to 0.096, 0.043 to 0.081, 0.039 to 0.055, 0.045 to 0.059, 0.033 to 0.067, 0.041 to 0.095, 0.035 to 0.059, 0.039 to 0.053, 0.041 to 0.056, 0.035 to 0.059, 0.042 to 0.067, 0.026 to 0.050, 0.021 to 0.052, 0.039 to 0.103, 0.026 to 0.063, 0.047 to 0.088, 0.021 to 0.049 and 0.028 to 0.059 mg L^{-1}, respectively.

The desirable and permissible limit of zinc is 5.0 and 15.0 mg L^{-1} for both drinking and irrigation purpose, hence all the water samples contain zinc concentration in water below the maximum permissible limit (BIS, 1991).

The concentration of zinc in ground water during summer season varied from 0.021 to 0.103 mg L^{-1} with a mean value of 0.05 mg L^{-1}, while 0.046 mg L^{-1} was an average value in monsoon season and its range was between 0.026 to 0.061 and 0.021 to 0.099 mg L^{-1} with a mean value of 0.050 mg L^{-1} during winter season.

In present study,the zinc concentration was lower during monsoon season due to dilution effect of rain water (Madhukar*et al.*, 2013) and higher during summer and winter due to depletion of water leading to greater concentration of metals and concentration effect (Thomas *et al.*, 2011). The similar trends were observed on Bidadi industrial area, Karnataka, India by Srikantaswamy*et al.*, (2013).

4.4.3 Copper

The data (Table 37) indicated that the copper concentration present in ground water ranged from 0.011 to 0.041, 0.019 to 0.081, 0.014 to 0.089, 0.015 to 0.078, BDL to 0.101, BDL to 0.091, 0.012 to 0.112, BDL to 0.099, BDL to 0.096, 0.015 to 0.101, 0.016 to 0.106, BDL to 0.111, 0.014 to 0.099, 0.016 to 0.118, 0.015 to 0.109, 0.019 to 0.101, 0.017 to 0.101, 0.026 to 0.109, 0.020 to 0.109 and 0.012 to 0.109 mg L^{-1} on well No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 in different months, respectively.

The desirable and maximum permissible limit of copper in drinking water is 0.05 and 1.5 mg L^{-1}, respectively, hence all water samples contain copper concentration below the maximum

Table 36. Variation in zinc concentration (mg L^{-1}) of ground water at different months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	0.065	0.051	0.054	0.056	0.051	0.052	0.050	0.052	0.052	0.051	0.076	0.065
2	0.057	0.044	0.054	0.042	0.044	0.041	0.052	0.061	0.062	0.047	0.047	0.089
3	0.047	0.047	0.044	0.042	0.026	0.031	0.057	0.096	0.056	0.035	0.031	0.032
4	0.064	0.081	0.061	0.046	0.047	0.046	0.043	0.044	0.053	0.057	0.052	0.049
5	0.053	0.041	0.044	0.042	0.047	0.051	0.055	0.043	0.049	0.042	0.043	0.039
6	0.059	0.045	0.046	0.048	0.048	0.049	0.048	0.045	0.048	0.050	0.051	0.047
7	0.067	0.050	0.033	0.043	0.049	0.051	0.053	0.061	0.054	0.043	0.059	0.048
8	0.047	0.046	0.061	0.041	0.046	0.052	0.047	0.041	0.079	0.095	0.078	0.068
9	0.045	0.053	0.037	0.042	0.035	0.042	0.059	0.041	0.043	0.045	0.049	0.041
10	0.048	0.039	0.048	0.041	0.041	0.041	0.050	0.050	0.053	0.051	0.043	0.039
11	0.050	0.047	0.051	0.042	0.056	0.056	0.050	0.045	0.047	0.048	0.041	0.043
12	0.058	0.043	0.035	0.048	0.051	0.059	0.059	0.039	0.043	0.045	0.049	0.059
13	0.044	0.045	0.044	0.042	0.046	0.046	0.043	0.044	0.049	0.053	0.056	0.067
14	0.050	0.048	0.046	0.044	0.048	0.041	0.039	0.041	0.038	0.038	0.031	0.026
15	0.052	0.044	0.041	0.038	0.039	0.048	0.052	0.048	0.039	0.029	0.032	0.021
16	0.057	0.039	0.056	0.045	0.049	0.052	0.050	0.057	0.068	0.087	0.099	0.103
17	0.055	0.063	0.039	0.042	0.046	0.051	0.055	0.051	0.048	0.044	0.031	0.026
18	0.052	0.047	0.048	0.051	0.048	0.059	0.056	0.051	0.059	0.088	0.067	0.058
19	0.049	0.034	0.034	0.029	0.033	0.036	0.033	0.037	0.032	0.026	0.021	0.024
20	0.053	0.049	0.036	0.036	0.043	0.045	0.059	0.051	0.049	0.034	0.031	0.028
Mean	**0.054**	**0.048**	**0.046**	**0.043**	**0.045**	**0.047**	**0.051**	**0.050**	**0.051**	**0.050**	**0.049**	**0.049**
Range	**0.044-0.067**	**0.034-0.081**	**0.033-0.061**	**0.029-0.056**	**0.026-0.056**	**0.031-0.059**	**0.033-0.059**	**0.037-0.096**	**0.032-0.079**	**0.026-0.095**	**0.021-0.099**	**0.021-0.103**

permissible limit (BIS, 1991).The desirable and permissible limit for irrigation purpose is 0.2 and 1.0 mg L^{-1} copper concentration in water (BIS, 1991). For irrigation purpose all water samples are safe throughout year. The low level due to adsorption process by the soil, which reduced the concentration of heavy metal in water (Agrawal*et al.*, 1987).

The copper concentration present in ground water ranged from BDL to 0.106 mg L^{-1} with a mean value of 0.045 mg L^{-1}, BDL to 0.118 mg L^{-1} with a mean value of 0.046 mg L^{-1} and 0.012 to 0.112 mg L^{-1} with a mean value of 0.068 mg L^{-1} during summer, monsoon and winter seasons, respectively.

Singh *et al.*, (2009) also found similar variation of copper concentration in ground water in Orissa, India.

4.4.4 Manganese

The perusal of data presented in Table 38 revealed that the different months on various well No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 contain concentration of manganese in water varied from 0.008 to 0.090, 0.008 to 0.095, 0.011 to 0.093, 0.006 to 0.092, 0.008 to 0.095, 0.008 to 0.097, 0.007 to 0.096, 0.009 to 0.097, 0.011 to 0.096, 0.011 to 0.089, 0.009 to 0.091, 0.009 to 0.092, 0.010 to 0.091, 0.009 to 0.091, 0.010 to 0.089, 0.008 to 0.089, 0.012 to 0.115, 0.016 to 0.093, 0.013 to 0.097 and 0.010 to 0.106 mg L-1, respectively.

The desirable and maximum permissible limit of manganese concentration in water is 0.05 and 0.5 mg L^{-1} for drinking purpose (BIS, 1991). In present study, the water samples contain manganese concentration below the maximum permissible limit throughout the year.

Environmental Study Board, (1973) the tolerance limit of manganese concentration in irrigation water for all type soil is 0.20 mg L^{-1}, hence all the well water samples contain manganese concentration below the tolerance limit and it safe for irrigation

Table 37. Variation in copper concentration (mgL^{-1}) of ground water at different months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	0.011	0.035	0.041	0.021	0.034	0.036	0.032	0.030	0.034	0.030	0.033	0.029
2	0.019	0.020	0.024	0.024	0.026	0.035	0.070	0.079	0.072	0.074	0.081	0.076
3	0.014	0.018	0.018	0.014	0.033	0.059	0.089	0.076	0.059	0.062	0.067	0.068
4	0.030	0.045	0.039	0.015	0.023	0.048	0.039	0.036	0.076	0.075	0.078	0.076
5	0.011	0.028	BDL	BDL	BDL	0.056	0.084	0.101	0.089	0.061	0.063	0.069
6	0.017	0.038	0.010	BDL	BDL	0.057	0.045	0.033	0.052	0.091	0.068	0.072
7	0.012	0.036	0.033	0.015	0.017	0.054	0.099	0.105	0.112	0.086	0.079	0.081
8	0.010	BDL	BDL	0.014	BDL	0.067	0.059	0.055	0.067	0.099	0.078	0.097
9	0.011	BDL	BDL	0.015	0.018	0.064	0.059	0.043	0.059	0.087	0.096	0.086
10	0.021	0.023	0.030	0.015	0.021	0.072	0.091	0.041	0.056	0.091	0.101	0.093
11	0.016	0.021	0.040	0.024	0.038	0.082	0.092	0.061	0.064	0.082	0.091	0.106
12	0.013	0.039	0.049	0.025	BDL	0.090	0.111	0.106	0.089	0.083	0.078	0.085
13	0.023	0.029	0.039	0.032	0.014	0.085	0.084	0.089	0.084	0.096	0.097	0.099
14	0.019	0.091	0.016	0.025	0.024	0.092	0.118	0.109	0.089	0.091	0.096	0.098
15	0.025	0.109	0.047	0.039	0.019	0.015	0.080	0.045	0.066	0.087	0.089	0.093
16	0.019	0.101	0.034	0.040	0.031	0.093	0.086	0.053	0.085	0.096	0.097	0.091
17	0.018	0.026	0.070	0.052	0.068	0.101	0.087	0.064	0.051	0.017	0.021	0.019
18	0.039	0.086	0.039	0.039	0.026	0.109	0.095	0.063	0.042	0.028	0.034	0.031
19	0.041	0.059	0.036	0.038	0.020	0.108	0.109	0.057	0.032	0.040	0.041	0.036
20	0.028	0.054	0.030	0.051	0.024	0.109	0.088	0.064	0.039	0.012	0.016	0.019
Mean	**0.020**	**0.043**	**0.030**	**0.025**	**0.022**	**0.072**	**0.081**	**0.066**	**0.066**	**0.069**	**0.070**	**0.071**
Range	**0.010-0.041**	**BDL-0.109**	**BDL-0.070**	**BDL-0.052**	**BDL-0.068**	**0.015-0.109**	**0.032-0.118**	**0.030-0.109**	**0.032-0.112**	**0.012-0.099**	**0.016-0.101**	**0.019-0.106**

BDL: Below Detection Limit

Table 38. Variation inmanganese concentration (mgL^{-1}) of ground water at different months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	0.081	0.090	0.047	0.039	0.029	0.020	0.009	0.008	0.011	0.019	0.016	0.031
2	0.095	0.090	0.037	0.034	0.028	0.020	0.008	0.010	0.016	0.029	0.026	0.039
3	0.069	0.093	0.032	0.034	0.029	0.017	0.011	0.014	0.019	0.022	0.026	0.029
4	0.076	0.092	0.024	0.037	0.033	0.023	0.006	0.010	0.009	0.022	0.027	0.027
5	0.086	0.095	0.023	0.033	0.029	0.024	0.008	0.011	0.022	0.031	0.024	0.022
6	0.079	0.097	0.091	0.020	0.027	0.025	0.008	0.019	0.028	0.052	0.056	0.051
7	0.083	0.096	0.020	0.031	0.029	0.023	0.007	0.008	0.019	0.037	0.041	0.047
8	0.078	0.097	0.023	0.034	0.031	0.024	0.009	0.011	0.024	0.031	0.034	0.036
9	0.081	0.096	0.027	0.033	0.027	0.023	0.011	0.013	0.019	0.034	0.034	0.034
10	0.087	0.089	0.045	0.039	0.032	0.024	0.016	0.011	0.013	0.046	0.045	0.049
11	0.088	0.091	0.034	0.027	0.027	0.025	0.009	0.014	0.014	0.021	0.02	0.023
12	0.087	0.092	0.067	0.044	0.039	0.022	0.009	0.012	0.032	0.037	0.036	0.038
13	0.091	0.089	0.052	0.029	0.037	0.025	0.011	0.010	0.036	0.061	0.061	0.063
14	0.091	0.088	0.067	0.037	0.036	0.021	0.009	0.016	0.027	0.032	0.035	0.031
15	0.089	0.087	0.055	0.051	0.035	0.022	0.010	0.016	0.028	0.036	0.039	0.039
16	0.086	0.089	0.041	0.039	0.029	0.027	0.008	0.020	0.022	0.042	0.041	0.041
17	0.088	0.096	0.115	0.012	0.037	0.029	0.018	0.014	0.021	0.035	0.047	0.041
18	0.089	0.093	0.072	0.053	0.034	0.032	0.017	0.016	0.023	0.029	0.031	0.036
19	0.091	0.097	0.089	0.057	0.030	0.024	0.013	0.017	0.028	0.031	0.022	0.025
20	0.092	0.095	0.106	0.061	0.036	0.026	0.010	0.015	0.019	0.021	0.021	0.029
Mean	**0.085**	**0.093**	**0.053**	**0.037**	**0.032**	**0.024**	**0.010**	**0.013**	**0.022**	**0.033**	**0.034**	**0.037**
Range	**0.069-0.095**	**0.087-0.097**	**0.020-0.115**	**0.012-0.061**	**0.027-0.039**	**0.017-0.032**	**0.006-0.018**	**0.008-0.020**	**0.009-0.036**	**0.019-0.061**	**0.016-0.061**	**0.022-0.063**

purpose.The concentration of manganese in ground water varied from 0.022 to 0.097, 0.006 to 0.115 and 0.008 to 0.061 mg L^{-1} with a mean value of 0.072, 0.031 and 0.026 mg L^{-1} during summer, monsoon and winter season, respectively.

In present study, manganese concentrations in ground water are higher in summer season and continuously decrease up to winter season. Bharti*et al.*, (2013) also found the similar results in variation of ground water on industrial area Haryana, India.

Mondol*et al.*, (2011) also observed the similar value due to effect of factory waste in ground water on the Tejgaon industrial area of Bangladesh.

4.4.5 Nickel

The data presented in Table 39 revealed that the nickel concentration in ground water varied from 0.027 to 0.069, 0.023 to 0.081, BDL to 0.083, 0.029 to 0.094, BDL to 0.096, BDL to 0.060, 0.029 to 0.072, 0.030 to 0.077, 0.044 to 0.085, 0.038 to 0.079, BDL to 0.074, 0.021 to 0.091, BDL to 0.097, 0.036 to 0.098, 0.021 to 0.093, BDL to 0.034, BDL to 0.049, 0.021 to 0.059 and BDL to 0.081 mg L^{-1} on various well No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20, respectively.

The maximum permissible limit of nickel concentration in drinking water is 0.02 mg L^{-1} (BIS, 1991). Throughout study, the most of water samples contain nickel concentration in ground water above the permissible limit for drinking purpose (BIS, 1991; WHO, 1984) due to the presence of water soluble salts (Kumar *et al.*, 2001) and leaching effect of heavy metal results as the excess amount of that metal in the ground water (Bharti*et al.*, 2013). In general, low pH also favors the exchangeable and soluble nickel concentration (Parth*et al.*, 2011).

The seasonal variation of nickel concentration in ground water summer season ranged from BDL to 0.097 mg L^{-1} with a mean value of 0.051 mg L^{-1}, while 0.041 mg L^{-1} was an average value during monsoon season and it ranged between BDL to 0.098 mg L^{-1} and BDL

Table 39. Variation innickel concentration (mgL^{-1}) of ground water at different months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	0.028	0.037	0.069	0.051	0.043	0.027	0.037	0.037	0.032	0.033	0.031	0.031
2	0.060	0.059	0.081	0.056	0.023	0.023	0.035	0.033	0.036	0.039	0.038	0.039
3	0.069	0.083	0.081	0.062	BDL	0.025	0.031	0.035	0.036	BDL	0.021	BDL
4	0.040	0.094	0.091	0.056	0.029	0.030	0.054	0.038	0.029	0.055	0.057	0.068
5	0.075	BDL	BDL	BDL	BDL	0.038	0.037	0.066	0.068	0.059	0.096	0.079
6	0.060	0.035	0.025	0.033	0.049	0.044	0.035	0.039	BDL	0.029	0.030	0.021
7	0.067	0.044	0.047	0.041	0.039	0.045	0.072	0.065	0.039	0.031	0.029	0.032
8	0.077	0.053	0.059	0.036	0.033	0.036	0.030	0.032	0.038	0.043	0.049	0.046
9	0.053	0.085	0.075	0.044	0.046	0.045	0.051	0.048	0.052	0.051	0.051	0.052
10	0.079	0.069	0.046	0.042	0.047	0.068	0.048	0.052	0.047	0.039	0.038	0.041
11	0.074	0.056	0.043	0.029	BDL	BDL	BDL	0.028	0.029	0.031	0.039	0.034
12	0.074	0.091	0.065	0.058	0.058	0.042	0.022	0.021	0.031	0.045	0.042	0.041
13	0.097	0.079	0.055	0.077	0.078	0.067	0.025	BDL	BDL	0.021	0.037	0.032
14	0.036	0.051	0.098	0.098	0.095	0.072	0.052	0.064	0.059	0.061	0.076	0.077
15	0.044	0.058	0.093	0.076	0.069	0.057	0.021	0.034	0.031	0.036	0.039	0.037
16	BDL	BDL	BDL	0.021	0.022	0.031	BDL	0.030	0.034	BDL	0.021	0.023
17	0.047	0.049	0.048	0.031	0.028	BDL	BDL	BDL	BDL	0.021	0.036	0.029
18	0.062	0.059	0.036	0.032	0.029	BDL	0.061	0.048	0.038	0.010	BDL	0.003
19	0.059	0.051	0.041	0.043	0.027	0.021	0.026	0.027	0.021	0.029	0.037	0.037
20	0.081	0.048	0.046	0.039	BDL	BDL	0.032	0.034	0.029	0.031	0.033	0.031
Mean	**0.059**	**0.055**	**0.055**	**0.046**	**0.036**	**0.034**	**0.033**	**0.037**	**0.032**	**0.033**	**0.040**	**0.038**
Range	**BDL-0.097**	**BDL-0.094**	**BDL-0.098**	**BDL-0.098**	**BDL-0.095**	**BDL-0.072**	**BDL-0.072**	**BDL-0.066**	**BDL-0.068**	**BDL-0.061**	**BDL-0.096**	**BDL-0.079**

BDL: Below Detection Limit

to 0.096 mg L^{-1} with a mean value of 0.036 mg L^{-1} in during winter season.Kumar *et al.*, (2013) also observed the similar variation in ground water of industrial area of Panipat, Haryana, India.

4.4.6 Chromium

The data (Table 40) indicated that the variation of chromium in ground water ranged from BDL to 0.095, BDL to 0.093, BDL to 0.051, BDL to 0.096, BDL to 0.086, BDL to 0.069, BDL to 0.074, BDL to 0.092, 0.028 to 0.055, BDL to 0.086, BDL to 0.026, BDL to 0.068, BDL to 0.088, 0.021 to 0.078, BDL to 0.070, BDL to 0.090, 0.030 to 0.089, BDL to 0.069, BDL to 0.090 and 0.031 to 0.093 mg L^{-1} on various well No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20,respectively at different months throughout the year.

The permissible limit of chromium concentration in water is 0.05 mg L^{-1} for drinking purpose (BIS, 1991; WHO, 1984).For irrigation purpose desirable and maximum permissible limit of chromium in water is 1.0 and 5.0 mg L^{-1}, respectively, hence all the water samples are also safe for irrigation purpose.

The seasonal variation of chromium in ground water during summer, monsoon and winter seasons varied from BDL to 0.096 mg L^{-1}, BDL to 0.090 mg L^{-1} and BDL to 0.086 mg L^{-1} with a mean value of 0.054, 0.030 and 0.039 mg L^{-1}, respectively.

In summer season, the samples contain chromium concentration in below the maximum permissible limit due to various anthropogenic activities, industrial effluents, old plumbing and household sewage (Warmate, 2011) and discharge of adjoining industries viz., tannery, chemical manufacturing etc. and also large amount of particular matter in the canal, which retained chromium as adsorbed ions (Mandol*et al.* 2011).

Madhukar*et al.*, (2013) observed the similar trends to effect of industrial effect on river water on Karnataka, India.

Table 40. Variation in chromium concentration (mgL^{-1}) of ground water at different months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	0.095	0.087	0.040	0.042	BDL	BDL	0.074	0.029	BDL	0.021	0.022	0.021
2	0.063	0.093	0.047	0.041	BDL	BDL	BDL	BDL	BDL	0.022	0.029	0.050
3	0.051	0.040	0.028	BDL	BDL	BDL	BDL	0.024	0.029	0.031	0.033	0.029
4	0.023	0.096	0.041	0.039	BDL	BDL	0.022	0.026	0.032	0.034	0.039	0.044
5	0.021	0.028	0.029	BDL	BDL	BDL	0.062	0.071	0.069	0.079	0.086	0.081
6	0.069	0.022	BDL	BDL	BDL	0.056	0.026	0.039	0.042	0.056	0.066	0.069
7	0.040	0.074	0.069	0.047	BDL	BDL	BDL	0.026	0.039	0.054	0.058	0.058
8	0.092	0.051	0.052	0.025	BDL	BDL	0.023	0.026	BDL	BDL	BDL	BDL
9	0.049	0.028	0.049	0.044	0.039	0.037	0.033	0.032	0.036	0.029	0.047	0.055
10	0.086	0.031	BDL	BDL	BDL	0.031	0.052	0.051	0.031	0.036	0.032	0.036
11	0.022	0.026	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.023	BDL	0.021
12	0.052	0.068	0.057	0.020	BDL	BDL	0.021	0.039	0.031	0.046	0.051	0.049
13	0.088	0.076	0.051	0.036	BDL	0.025	0.058	0.051	0.051	0.054	0.062	0.066
14	0.074	0.022	0.021	0.067	0.044	0.071	0.073	0.077	0.076	0.078	0.077	0.071
15	0.037	0.028	BDL	0.050	0.070	0.018	0.058	0.035	0.039	0.054	0.051	0.054
16	0.090	0.064	0.061	0.023	BDL	0.039	0.036	0.038	0.039	0.048	0.052	0.049
17	0.061	0.041	0.086	0.089	0.059	0.056	0.033	0.031	0.037	0.030	0.069	0.071
18	0.043	0.055	BDL	0.031	0.035	0.039	0.034	0.067	0.061	0.069	0.061	0.063
19	0.061	0.051	0.051	0.049	0.052	0.069	0.090	0.080	BDL	BDL	BDL	0.021
20	0.082	0.093	0.067	0.051	0.039	0.051	0.067	0.036	0.031	0.046	0.041	0.043
Mean	**0.060**	**0.054**	**0.037**	**0.033**	**0.017**	**0.025**	**0.038**	**0.039**	**0.032**	**0.041**	**0.044**	**0.048**
Range	**0.021 0.095**	**0.022 0.096**	**BDL-0.086**	**BDL-0.089**	**BDL-0.070**	**BDL-0.071**	**BDL-0.090**	**BDL-0.080**	**BDL-0.076**	**BDL-0.079**	**BDL-0.086**	**BDL-0.081**

BDL: Below Detection Limit

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4.4.7 Cobalt

The perusal of data presented in Table 41 revealed that the well No. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 are contain cobalt concentration in ground water varied from BDL to 0.011, BDL to 0.008, BDL to 0.011, BDL to 0.015, BDL to 0.011, BDL to 0.050, BDL to 0.070, BDL to 0.011, BDL to 0.021, BDL to 0.010, BDL to 0.014, BDL to 0.013, BDL to 0.050, BDL to 0.018, BDL to 0.030, BDL to 0.023, BDL to 0.008, BDL to 0.013, 0.009 to 0.015 and BDL to 0.023 mg L^{-1}, respectively throughout the year.

The desirable and permissible limit of cobalt concentration is 0.05 and 1.5 mg L^{-1} in irrigation water, respectively (BIS, 1991), henceall the water samples contain cobalt concentration in ground water below the maximum permissible limit and safe for irrigation purpose.

The concentration of cobalt in ground water during summer, monsoon and winter season varied from BDL to 0.021 mg L^{-1} with a mean value of 0.008 mg L^{-1}, BDL to 0.021 mg L^{-1} with a mean value of 0.005 mg L^{-1} and BDL to 0.023 mg L^{-1} with an average value of 0.008 mg L^{-1}, respectively. During monsoon season cobalt concentration is lower in ground water as compared to summer and winter season due to heavy rainfall (Mondol*et al.*, 2011)

Singh *et al.*, (2009) observed the similar trends in ground water of Angul-Talcher region of Orissa, India.

4.4.8 Lead

The concentration of lead was not found in any water samples throughout year.

Table 41. Variation incobalt concentration (mgL^{-1}) of ground water at different months from Lote MIDC

Sample No.	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1	BDL	BDL	BDL	0.001	BDL	BDL	0.003	0.006	0.009	0.011	0.011	0.011
2	BDL	BDL	BDL	0.003	BDL	BDL	0.002	0.008	0.008	0.007	0.006	BDL
3	BDL	0.011	0.003	BDL	BDL	BDL	0.006	0.002	0.001	0.002	0.003	BDL
4	BDL	0.009	0.009	0.006	0.003	0.014	0.009	0.006	0.009	0.006	0.007	0.015
5	BDL	0.005	BDL	BDL	0.003	0.006	0.011	0.011	0.008	BDL	0.009	0.011
6	BDL	BDL	0.003	0.019	0.011	0.011	0.008	0.005	0.050	0.011	0.009	0.007
7	BDL	0.070	0.014	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
8	BDL	0.011	0.01	BDL	BDL	0.005	0.005	0.004	0.002	0.011	0.009	0.009
9	0.018	0.021	0.017	0.007	BDL	0.001	BDL	0.006	0.004	0.008	0.011	0.011
10	0.001	0.006	BDL	0.001	BDL	BDL	BDL	BDL	0.001	0.007	0.009	0.010
11	BDL	0.009	0.005	BDL	0.002	0.014	0.011	0.005	0.003	0.011	0.004	0.006
12	0.001	BDL	BDL	BDL	0.004	BDL	0.005	0.005	0.002	0.013	BDL	BDL
13	0.020	0.050	0.007	BDL	0.011	0.012	BDL	BDL	0.009	0.011	0.012	0.011
14	0.018	BDL	0.006	BDL	BDL	0.007	0.009	0.008	0.011	0.012	0.011	0.013
15	0.017	BDL	0.030	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
16	0.011	BDL	BDL	BDL	BDL	BDL	BDL	0.017	0.019	0.023	0.019	0.021
17	0.008	0.005	0.003	BDL	BDL	BDL	BDL	BDL	0.001	0.003	0.005	BDL
18	BDL	0.003	0.001	0.009	0.008	0.009	0.011	0.008	0.009	0.013	0.011	0.012
19	0.011	0.009	0.012	0.011	0.014	0.011	0.009	0.011	0.012	0.012	0.015	0.011
20	BDL	0.011	0.018	0.021	BDL	0.008	0.013	0.017	0.022	0.021	0.023	0.020
Mean	**0.005**	**0.011**	**0.007**	**0.004**	**0.003**	**0.005**	**0.005**	**0.006**	**0.009**	**0.009**	**0.009**	**0.008**
Range	**BDL-0.020**	**BDL-0.021**	**BDL-0.030**	**BDL-0.021**	**BDL-0.014**	**BDL-0.014**	**BDL-0.013**	**BDL-0.017**	**BDL-0.022**	**BDL-0.023**	**BDL-0.023**	**BDL-0.020**

BDL: Below Detection Limit

CHAPTER V
SUMMARY AND CONCLUSION

The present investigation entitled, "Effect of factory waste on soil and ground water quality from Lote M.I.D.C."tehsil-Khed, Dist. Ratnagiri (M.S.) was carried out and the analytical work was done in the research laboratory of the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. BalasahebSawantKonkanKrishi Vidyapeeth, Dapoli during the academic year 2013-2015.

For the present investigation Maharashtra Industrial Development Corporation (MIDC) Lotewas selected for soil and water sample collection. The surface soil samples were collected during pre and post-monsoon season from the selected locations. Thus, in all 30 surface soil samples were collected from selected area in the month of May and October 2014.The ground water samples collection started from April 2014 up to March 2015 at one month interval throughout the year. The important findings evolved from the present investigation are briefly summarized and concluded in this chapter.

5.1 Physico-chemical properties of soil

5.1.1 pH

The pH of soil varied from 4.15 to 5.14 with an average value of 4.45 and 3.89 to 6.03 with a mean value of 4.50 inpre-monsoon season and post-monsoon seasons, respectively.

5.1.2 Electrical conductivity

The electrical conductivity of soil in pre-monsoon season varied from 0.051 to 0.094 dSm^{-1} with an average value of 0.067 dSm^{-1}, while for post-monsoon season it showed variation from 0.047 to 0.114 with a mean value of 0.072 dSm^{-1}.

5.1.3 Organic carbon

The organic carbon in soil from different soil samples ranged from 0.95 to 2.63 per cent with a mean value 1.94 per cent and 1.77 to 3.07 per cent with a mean value 2.37 per cent in pre and post- monsoon seasons, respectively.

5.1.4 Available nitrogen

The available nitrogen in soil samples ranged from 235.20 to 454.72 kg ha^{-1} with a mean value of 365.83 kg ha^{-1} and 235.20 to 392.28 kg ha^{-1} with an average value of 301.89 kg ha^{-1} in pre and post-monsoon seasons, respectively.

5.1.5 Available phosphorus

The available phosphorus in soil samples ranged from 3.55 to 13.51 kg ha^{-1} with a mean value of 6.87 kg ha^{-1} and 3.12 to 7.11 kg ha^{-1} with an average value of 5.78 kg ha^{-1} in pre and post-monsoon seasons, respectively.

5.1.6 Available potassium

The available potassium in soil samples ranged from 114.24 to 302.20 kg ha^{-1} with a mean value of 168.37 kg $ha^{-1}$and 92.96 to 230.72 kg ha^{-1} with an average value of 130.58 kg ha^{-1} in pre and post-monsoon seasons, respectively.

5.1.7 Exchangeable calcium

The exchangeable calcium in soil samples ranged from 1.7 to 8.1 meq100^{-1} g with a mean value of 3.98 meq100^{-1}g and 1.4 to 5.4 meq100^{-1}g with a mean value of 2.91 meq100^{-1}g in pre and post-monsoon seasons, respectively.

5.1.8 Exchangeable magnesium

The exchangeable magnesium in soil from different samples ranged from 0 to 2.1 meq100^{-1}g with a mean value of 0.82 meq100^{-1}g and 0 to 1.8 meq100^{-1}g with an average value of 0.65 meq100^{-1}g in pre and post-monsoon seasons, respectively.

5.1.9 Available sulphur

The available sulphur in soil had the range from 2.42 to 38.75 mg kg^{-1} with an average value of 12.55 mg kg^{-1} and 1.21 to 63.58 mg kg^{-1} with a mean value of 16.27 mg kg^{-1} in pre and post-monsoon seasons, respectively.

5.1.10 Micronutrients and heavy metals in soil

The iron content in soil an average value of 80.70 mg kg^{-1}in pre-monsoon season, while it decreased in post-monsoon with a mean value of 77.52 mg kg^{-1}. The available micronutrient viz., zinc, copper and manganese were present in soil with a mean value of 0.60, 4.94 and 53.11 mg kg^{-1} in pre-monsoon season while in post-monsoon season, soil contained an average value of 2.76, 6.19 and 53.17 mg kg^{-1}, respectively. The available zinc, copper and manganese increased during post-monsoon season.

The heavy metal nickel concentration in soil had an average value of 0.96 mg kg^{-1} in pre-monsoon, while it decreased in post-monsoon season with a mean value of 0.69 mg kg^{-1}. The lead concentration in soil during pre and post-monsoon season had mean values 1.73 mg $kg^{-1}$and 1.61 mg kg^{-1}, respectively. The chromium concentration in pre and post-monsoon season had an average value of 0.69 mg $kg^{-1}$and 0.83 mg kg^{-1}, while cobalt concentration in soil was 0.56mg kg^{-1} and 1.10 mg kg^{-1} in pre and post-monsoon season, respectively. The chromium and cobalt concentration increased in post-monsoon season.

5.2 Physico-chemical parameters of ground water

5.2.1 pH

The pH of ground water in different season varied from 5.25 to 8.97, 4.67 to 8.40 and 4.90 to 6.98 with a mean value of 6.08, 5.77 and 5.89 in summer, monsoon and winter seasons, respectively.

5.2.2 Electrical conductivity

The electrical conductivity of ground water varied from 0.018 to 0.792, 0.030 to 1.196 and 0.033 to 0.781 dSm^{-1} with a mean value of 0.150, 0.166 and 0.185 dSm^{-1} during summer, monsoon and winter seasons, respectively.

5.2.3 Bicarbonate

The bicarbonate concentration of water varied from 31.61 to 170.83, 24.20 to 195.20 and 31.61 to 158.63 mg L^{-1} with an averagevalue of 84.74, 68.69 and 80.84 mg L^{-1} during summer, monsoon and winter seasons, respectively.

5.2.4 Chloride

The seasonal variation of chloride concentration in ground water varied from 113.47 to 297.86, 99.29 to 482.26 and 141.84 to 354.60 mg $L^{-1}$with a mean value of 199.99, 198.43 and 209.22mg L^{-1}during summer, monsoon and winter seasons, respectively.

5.2.5 Sodium

The sodium concentration of ground water ranged from 3.10 to 202.00, 2.10 to 68.90 and 2.90 to 78.60 ppm with a mean value of 18.53, 9.34 and 11.81 ppm during summer, monsoon and winter seasons, respectively.

5.2.6Calcium

The calcium concentration in ground water ranged from 12.02 to 124.25, 8.02 to 112.22 and 8.02 to 84.17 mg L^{-1} with an average value of 37.77, 30.70 and 26.15 mg L^{-1} during summer, monsoon and winter seasons, respectively.

5.2.7 Magnesium

The variation of magnesium concentration in ground water in different seasons varied from 0.00 to 82.69, 0.00 to 58.37 and 0.00 to 38.91 mg L^{-1} with a mean value of 9.57, 8.27 and 5.32 mg L^{-1} during summer, monsoon and winter seasons, respectively.

5.2.8Sodium Adsorption Ratio

The seasonal variation in ground water as Sodium Adsorption Ratio varied from 0.182 to 5.790, 0.118 to 2.521 and 0.188 to 3.334 with a mean value of 0.883, 0.543 and 0.758 during summer, monsoon and winter seasons, respectively.

5.2.9 Residual Sodium Carbonate

The Residual Sodium Carbonate value in ground water ranged from -0.71 to 2.17, -0.81 to 2.39 and 0.05 to 1.63 with a mean value of 0.58, 0.42 and 0.70 during summer, monsoon and winter seasons, respectively.

5.3 Micronutrient and heavy metal concentration in ground water

5.3.1 Iron

The iron concentration in ground water varied from 0.010 to 0.117, 0.027 to 0.124 and 0.010 to 0.111 mgL^{-1} with a mean value of 0.073, 0.075 and 0.076 mgL^{-1} during summer, monsoon and winter seasons, respectively.

5.3.2 Zinc

The concentration of zinc in ground water insummer season varied from 0.021 to 0.103 mg L^{-1} with a mean value of 0.050 mg L^{-1}, while 0.046 mg L^{-1} was an average value in monsoon season and it ranged between 0.026 to 0.061 and 0.021 to 0.099 mg L^{-1} with a mean value of 0.050 mg L^{-1} during winter season.

5.3.3Copper

The Cu concentration present in ground water ranged from BDL to 0.106 mg L^{-1} with a mean value of 0.045 mg L^{-1}, BDL to 0.118 mg L^{-1} with a mean value of 0.046 mg L^{-1} and 0.012 to 0.112 mg L^{-1} with a mean value of 0.068 mg L^{-1} during summer, monsoon and winter seasons, respectively.

5.3.4Manganese

The concentration of manganese in ground water varied from 0.022 to 0.097, 0.006 to 0.115 and 0.008 to 0.061 mg L^{-1} with a mean value of 0.072, 0.031 and 0.026 mg L^{-1} during summer, monsoon and winter seasons, respectively.

5.3.5Nickel

The seasonal variation of nickel concentration in ground water duringsummer season ranged from BDL to 0.097 mg $L^{-1}$with a mean value of 0.051 mg L^{-1} while 0.041 mg $L^{-1}$was an average value on during monsoon season and it ranged between BDL to 0.098 mg L^{-1} and BDL to 0.096 mg L^{-1} with mean value of 0.036 mg L^{-1}during winter season.

5.3.6 Chromium

The seasonal variation of chromiumconcentration in ground water during summer, monsoon and winter season varied from BDL to 0.096mg L^{-1}, BDL to 0.090mg L^{-1} and BDL to 0.086 mg L^{-1} with a mean value of 0.054, 0.030 and 0.039 mg L^{-1}, respectively.

5.3.7 Cobalt

The concentration of cobalt in ground water during summer, monsoon and winter season varied from BDL to 0.021mg $L^{-1}$with a mean value of 0.008mg L^{-1}, BDL to 0.021mg L^{-1} with an average value of 0.005mg $L^{-1}$and BDL to 0.023 mg L^{-1} with an average value of 0.008 mg L^{-1}, respectively.

5.3.8 Lead

The concentration of lead in all ground water samples was below detection limit.

Conclusion:

In present studyconducted atLote MIDC, Dist. Ratnagiri (M.S.) in 2014-2015. The physico-chemical properties of soil samples recorded micronutrient and minerals as a normal soil. There are no adverse effects of industrial waste on soil. The heavy metal concentrations were found below the maximum permissible limit in soil and water. However, the concentration of nickel in some samples was observed above the permissible limit. Throughout year, the ground water was safe for irrigation purpose.

However, the long term studies about contamination of soil and ground water need to be examined.

Implications:

However, long term use of water needs caution about level of heavy metals and also periodical soil health monitoring is essential.

CONTENTS

Plate 2. Map of so

il and water sampling area Lote MIDC, district Ratnagiri (M.S.)

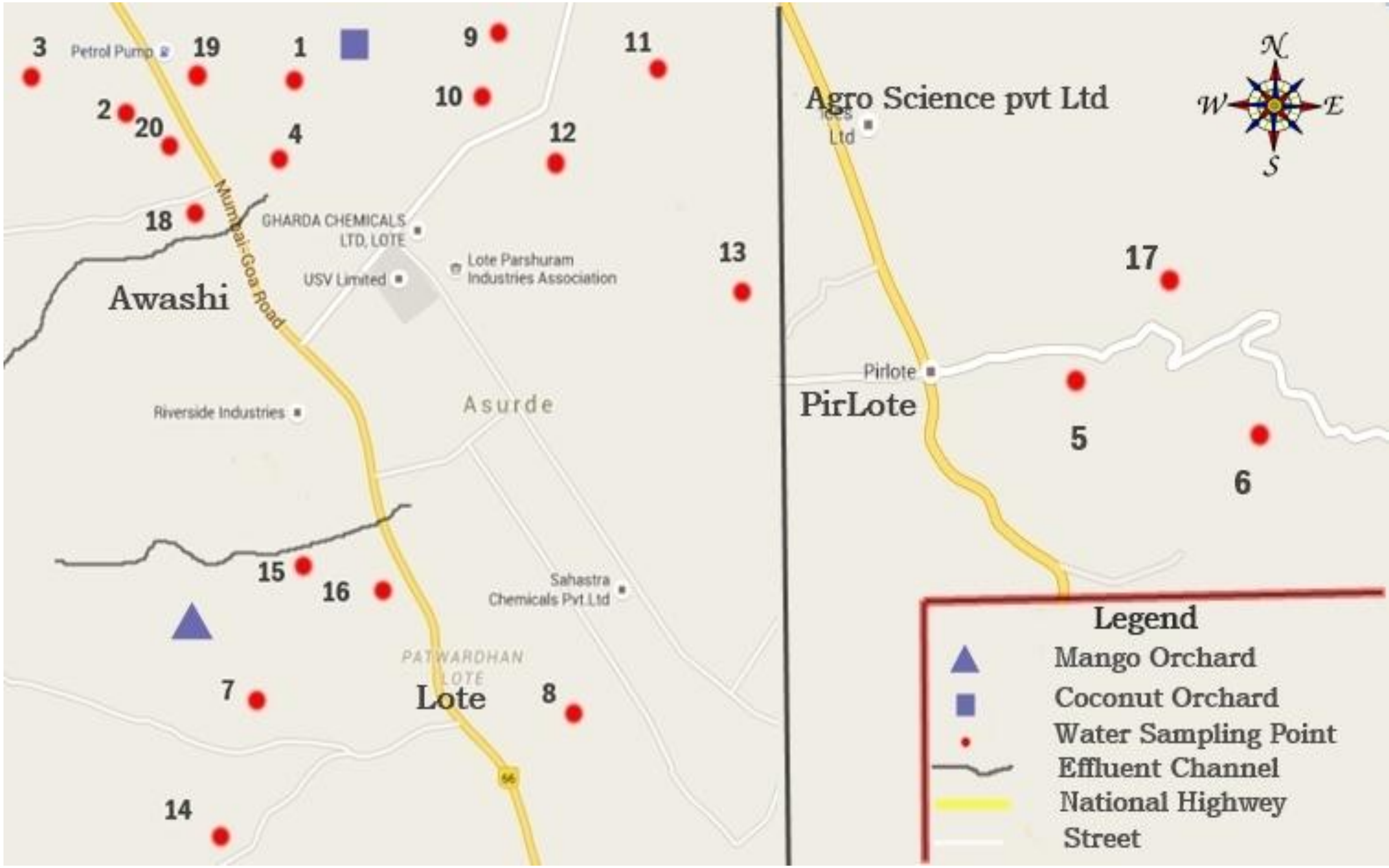

Plate1. Map of study area Lote MIDC, Dist. Ratnagiri (M.S.)

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* Original not seen

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