

# **ASSESSMENT OF GROUND WATER QUALITY NEAR ANIMAL FARMS IN AND AROUND PATIALA**

A Thesis submitted to

**THAPAR INSTITUTE OF ENGINEERING & TECHNOLOGY, PATIALA**

in partial fulfillment of the requirements

For the award of degree of

**MASTER OF TECHNOLOGY**

in

**ENVIRONMENTAL SCIENCES & TECHNOLOGY**

by

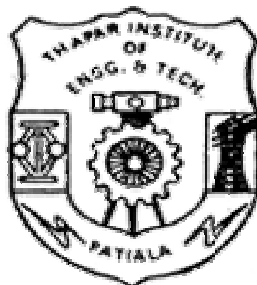
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**PATIALA -147004**

**June 2006**

## **DECLARATION**

I hereby declare, that the thesis report entitled, “*Assessment of Ground Water Quality near Animal Farms in and around Patiala*” written and submitted by me to Thapar Institute of Engineering & Technology (Deemed University), Patiala, in partial fulfillment of the requirements for the degree of **MASTER of TECHNOLOGY in ENVIRONMENTAL SCIENCES & TECHNOLOGY**. This is my original work & conclusions drawn are based on material collected by me.

I further declare that this work has not been submitted to this or any other university till now for the award of any other degree, diploma or equivalent course.

**PIYUSH SINGH**

## **ACKNOWLEDGEMENT**

I wish to express my deep gratitude to Mr. K. S. Babu, Lecturer and Dr. Anita Rajor, Lab. Superintendent, Department of Biotech. & Env. Sciences, Thapar Institute of Engineering & Technology, Patiala for their valuable guidance, inspiration, valuable suggestions and encouragement during the entire period of present study.

I would like to acknowledge timely advice extended and constant encouragement by Dr. A.S. Reddy, Asst. Professor, Department of Biotech. & Env. Sciences.

I will not hesitate to express sincere thanks to Satluj monitoring project (SMP) staff for providing me help to perform the Lab experiment works.

I am also very thankful to Faculty of Department of Biotech. & Env. Sciences, Thapar Institute of Engineering & Technology, Patiala for giving the important suggestions at the time of monitoring seminars.

Lastly, I am thankful to my colleagues, friends and family members for bearing me and providing me all moral help during the entire period of my work.

**PIYUSH SINGH**

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# CHAPTER: 1 INTRODUCTION

## 1.1 General

Mankind has (purposely or negligibly) forgotten that we are not alone on this planet, and the ecosystem and its plentiful (but not unlimited) resources do not exclusively belong to us. Although we may have the “divine” entitlement (and obligation) to utilize, develop and indeed enjoy these resources for our wellbeing and prosperity, we have no right whatever to alter, abuse, damage, and/or overexploit such wealth at the expense of rest of earth’s fellow residents or future human generations. Even if we try, with all of our technological advancement and affluence, to remedy our old/new environmental mistakes, we will not be successful without the sustainable aid of nature itself. Nature has the strength to rectify assault, assimilate alien substances and phenomena’s, attenuate toxins, mitigate injuries and purify it self.

Water is a vital natural resource which is essential for a multiplicity of purposes. Its many uses include drinking and other domestic uses, industrial cooling, power generation, agriculture, transportation and waste disposal. In the chemical process industry water is used as reaction medium, a solvent, a scrubbing medium, and a heat transfer agent. As a source of life for man, plants and other forms of life it can not be replaced.

Freshwater constitutes only a very little portion of the global water on earth. Less than 3 % of the world’s water is fresh, and most of this (nearly 70%) is in the ground, ice caps, and glaciers.

Moreover less than 1 percent of the world’s freshwater, or about 0.007 percent of all water on Earth, is readily accessible for direct human use. This is the water found in lakes, rivers, reservoirs and those underground sources that are shallow enough to be tapped at an affordable cost. Only this amount is regularly renewed by rainfall and snowfall, and therefore available on a sustainable basis.

Water available below the ground surface is termed as ground water and this occurs as surface water (rain/melting snow) infiltrates into the ground surface and percolate deep into the ground and is stored as ground water. This recharge of ground water also occurs from

excess irrigation, seepage from canals, leakages from reservoirs etc. The ground water held by geological formations is not static but is slowly moving in the lateral direction to some point of escape.

Surface water is majorly used for domestic and industrial activities whereas in India the demand for irrigation is met by ground water.

Ground water is generally purer than surface water. Yet it may contain some natural impurities or contaminants, even with no human activity or pollution. Natural contaminants can come from many conditions in the watershed or in the ground. Water moving through underground rocks and soils may pick up magnesium, calcium and chlorides. Some ground water naturally contains dissolved elements such as arsenic, boron, selenium, or radon, a gas formed by the natural breakdown of radioactive uranium in soil.

Its quality also depends on the depth of water table from surface (shallow/deep), quantity of new water entering into it and chances of being polluted by humans. Pollution of ground water by human activities is classified in three categories

- **Ground water contamination from Municipal Wastes:** Domestic sewage containing organic matter, detergents and fecal matter etc. pollute the ground water.
- **Groundwater contamination from Industrial wastes:** The industrial wastewater emit chemicals, toxic substances, metals and other pollutants which pollute the ground water.
- **Groundwater contamination due to Agriculture and Animal husbandry:** Agriculture and animal husbandry also contributes to ground water contamination. In agriculture large amount of pesticides, insecticides and fertilizers are used which degrade the quality of water. Animal husbandry activities are also responsible for surface and ground water contamination.

## 1.2 Livestock Production

Animal agriculture is one of the most important components of global agriculture. For example, livestock use 3.3 billion hectares of grazing land and the production from about one-quarter of the world's croplands. In total, livestock make use of more than two-thirds of the world's surface under agriculture, and one-third of the total global land area. Livestock raising is the sole source of livelihood for at least 20 million pastoral families, and an important source of income for at least 200 million smallholder farmer families in Asia, Africa and Latin America (FAO 1996).

The way livestock are kept and milk and meat is produced will be a key factor in the future health of the planet. Livestock production, mainly as a result of increasing demand, has become an important factor in environmental degradation. Large land areas have become degraded through overgrazing and deforestation because of ranching. Biodiversity is affected by extensive, as well as intensive, livestock production. Livestock are an important source of gaseous emissions (mainly methane and carbon dioxide) contributing to global warming. Where animal concentrations are high, land and water may be polluted through waste from animal production and processing.

One of the great challenges facing the world over the next decade is to identify policies and technologies which mitigate any negative environmental impact, while at the same time producing sufficient livestock products to satisfy the demands of a growing human population.

### **1.3 Effects of Livestock Production on Ground Water**

Pollution from surface and ground water from animal waste is of growing environmental concern. High loading rates of sediment, Nitrogen, Phosphorus and Pathogens to soil and waters can occur from animal operations, such as grazing (Guan and Holley, 2003). High N concentrations entering streams or lakes may also contribute to eutrophication. Phosphate is adsorbed on to sediments and can be transported with the sediments to lakes and streams where its most significant effect is eutrophication. Animal waste is the source of microorganisms pathogenic to humans. When surface runoff or leaching occurs due to excessive irrigation or rainfall, contamination of water resources by enteric bacteria may result in health hazards (Guan and Holley, 2003).

### **1.4 Scenario of Livestock Production in Punjab**

The state of Punjab, located in the North region of the country, has a geographic area of 50,362 sq.km., which is 1.5 % of the country's geographic area. In 2001, Punjab has a

total human population of 24.29 million (2.4 % of the country's population). The rural population is 66.1 % and urban population is 33.9 % and the population density of 482 persons per sq.km.

Punjab is one of the richest states in India, having experienced the highest rates of economic growth in the country until recently. Primary production forms the basis for its strong economy, with agricultural crop husbandry experiencing phenomenal growth since the introduction of the Green Revolution in the mid 1960s. More recently, Punjab has ushered in the 'White Revolution', with the state having recorded the highest per capita availability of milk under the Operation Flood (In 2003-2004, the availability of milk in Punjab was 896 grams per capita per day). Animal husbandry is already the second most important income and employment generating activity in rural Punjab, accounting for 14.25% of state income in 2003-04.

Table 1.1 shows the type of animal with their population in Punjab. As per the last 17<sup>th</sup> livestock census, the state of Punjab had 1.10% of Cattle, 6.12% of buffaloes, 0.36% of sheep, 0.22% of goats and 0.22% of pig population of the country. The poultry population is 2.2% of the country's total poultry population .

**Table1.1 Animal population in Punjab**

<b>Livestock</b>	<b>Year 1997</b>	<b>Year 2003</b>
Crossbred cattle	1828	1531
Indigenous cattle	810	508
Total cattle	2638	2039
Buffaloes	6171	5995
Total Bovine	8809	8034
Sheep	436	220
Goats	414	278
Pigs	96	29
Others	103	46
<b>Total Livestock</b>	<b>9858</b>	<b>8607</b>

**Source**-Ministry of Agriculture, Department of Animal Husbandry and Dairying

Several dwellers in and around the city Patiala, a district in Punjab, keep the domestic animals in their vicinities. The animal farms are small to big, the number of animals varying from 5 to 300 respectively. The leftover feed, animal waste generated in the farms (solid animal dung) is made to a heap near the dwellings. This attracts flies and liberates odours. The liquid (animal urine) as well as leachate from heap percolate into soil.

The Ground water level in Patiala is shallow to medium. The ground water withdrawal (hand pump/submersible pump) is found very close to animal farms which in turns affects the health of city people. With a view to protect the well being of the people State Pollution Control Board and City Municipality served several notice to shift their animal farms outskirts the city.

**As indicated above, animal farms are clearly a source of ground water contamination. Hence the objective of the study is to assess the ground water quality around animal farms of city. In fulfilling the objectives, the work elements such as source study, characterization of soil are considered. The findings will contribute to examine the relationship between livestock and water quality.**

# CHAPTER: 2 REVIEW OF LITERATURE

## 2.1 Background

The sources of water are Surface and Subsurface water. Surface water percolates deep and is stored as groundwater. The geological formation harbouring water may be

- Aquifer (permits storage as well as transmission of water. eg: Sand)
- Aquiclude (permits storage but not capable of transmitting water. eg :Clay)
- Aquitard (permits storage but does't yield water freely. eg : Sandy/Clay)
- Aquifuge (does't store as well as does't transmit water. eg : Granite)

The two characteristics of geological formation dictating movement of water in soil are

- Porosity
- Permeability

Porosity is a measure of capacity of the formation to contain water, whereas permeability is the property of a porous medium by virtue of which water can flow through it. Porosity of soils ranges from 20% for graded sand to 65% for heavy clays. Sandy soil have high permeability with a low value for clayey soil.

Water can be derived from ground as

- Open wells
- Tube wells

Open wells generally extracts water from top water bearing strata. The yield is less (Dia.=1-10 mm, Depth =2-20 meter, Yield = 20 m<sup>3</sup>/h) and subject to failures such as cavitation easily. A tube well is a long pipe sunk into the ground intercepting one or more water bearing strata. The yield are higher (Diameter =80-600 mm, Depth =30-600m, Yield =20-800 m<sup>3</sup>/h) and possibility of failure is minimal.

Groundwater is a low cost high quality source whereas surfaced water is a high cost low quality source. The Groundwater quality depends on depth of water table from ground surface, type of geological formations, amount of water recharging the aquifer, source of

pollution etc. The various causes of Groundwater pollution and consequent deterioration of its quality are given below-

The groundwater may get polluted on account of infiltration and percolation of

- Domestic and municipal sewage from septic tanks, waste water disposal ponds etc.
- Industrial wastes
- Organic wastes from food processing industry, timber processing industry etc.
- Mineral wastes from metal processing industry, mining and ore extraction industry, etc.
- Waste from Oil industry, Chemical industry, etc.
- Rain falling on sanitary land fills

The quality of groundwater may get degraded due to

- Infiltration and percolation of irrigation return water contaminated with dissolved fertilizer and disinfectants used for cultivation.
- Interchange between aquifers due to differential in pressure level resulting from excessive withdraw
- Overdraft conditions, i.e. Withdrawal far in excess of the quantity of water recharged or recouped
- Sea water intrusion into the aquifer
- Upward on lateral diffusion of comate brines and/or juvenile water due to over pumping.
- Contamination from the dirty surface water
- Inflow and/or percolations of juvenile water from highly mineralized springs and streams
- Mineralization resulting from plant transpiration and/on evaporation

The Table 2.1 shows the extent of contamination of Ground Water in India with variety of pollutants.

**Table 2.1 Contamination of ground water in India with varieties of pollutants.**

State	Pollutants	Level
AP, Gujarat, Haryana, Karnataka, M.P Maharashtra, Bihar, Delhi	Fluoride	11 mg/l
West Bengal	Arsenic	0.05-3.2 mg/l
Rajasthan, Punjab	Salinity	11.30 ds /cm
Gujarat	Oil from Refinery	NR
Rural Area of Delhi	Nirate	NR

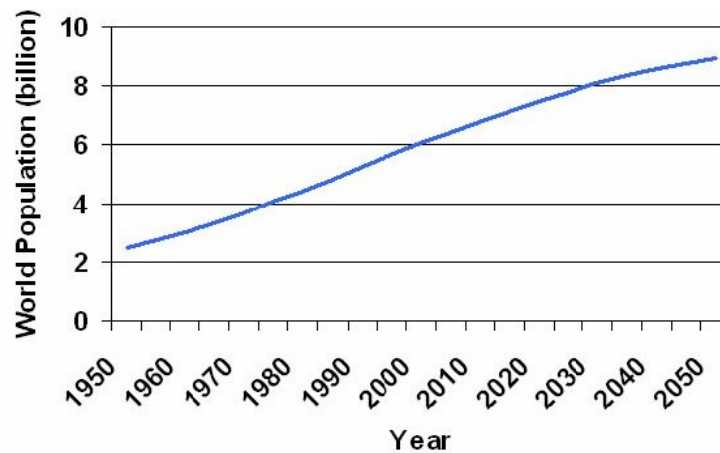
**Sources:** Ministry of Water Resources 2000.

The information furnished above shows that sources of Groundwater contamination are multiple. Livestock production is a major component of global agriculture. A close relationship exists between Livestock and Human population of any country and the same is shown in the subsequent paragraphs.

## **2.2 Livestock Production and Human Needs**

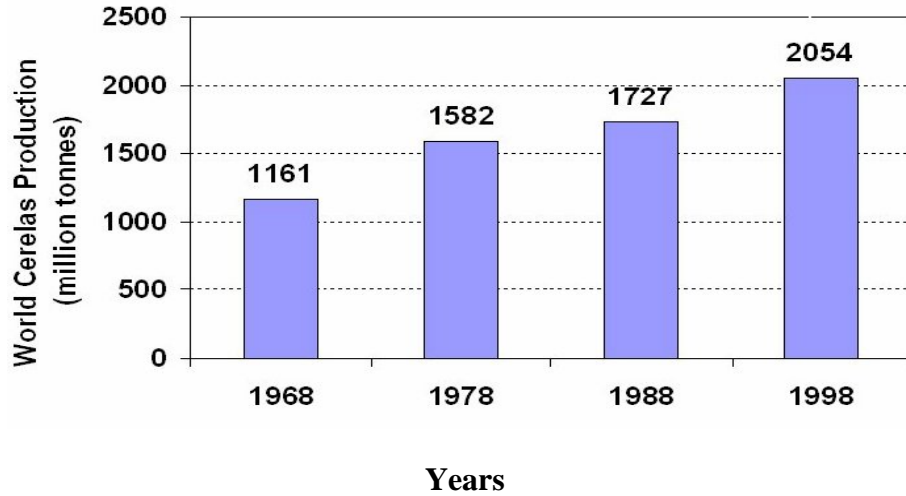
Food production has expanded enormously in the past three decades, paralleling the growth in the world's population from 3.5 billion in 1968 to 5.9 billion in 1998 (See Figure 2.1). The world cereals harvest almost doubled between 1968 and 1998, from 1161 to 2054 million tonnes ( Figure 2.2) while meat production nearly tripled, from 83 million to 222 million tonnes (See Figure 2.3). The increase in cereals harvest was due to a combination of improved grain varieties, greater fertilizer and pesticide use and irrigation, and rapid growth of food imports. Total meat production in the developing

countries exceeded that of the developed world in 1998. There was a small net inflow to the developing countries in internationally traded meat and meat products. The importance of livestock production can be expected to increase over the next decades. While in the industrial world, demand for meat and milk will probably plateau, or even decline, in the developing world, income growth and urbanization will fuel a strong increase in demand. Current levels of meat consumption in the developing world are only about one-third of those in the industrial world. However, specialists of the International Food Policy Research Institute (IFPRI) estimate that the demand of 209 million tons of meat in 1997 may rise to 327 million tons of meat by the year 2020. Moreover, it will be especially strong in Asia and Africa where the demand for meat is expected to triple (IFPRI, 1999).



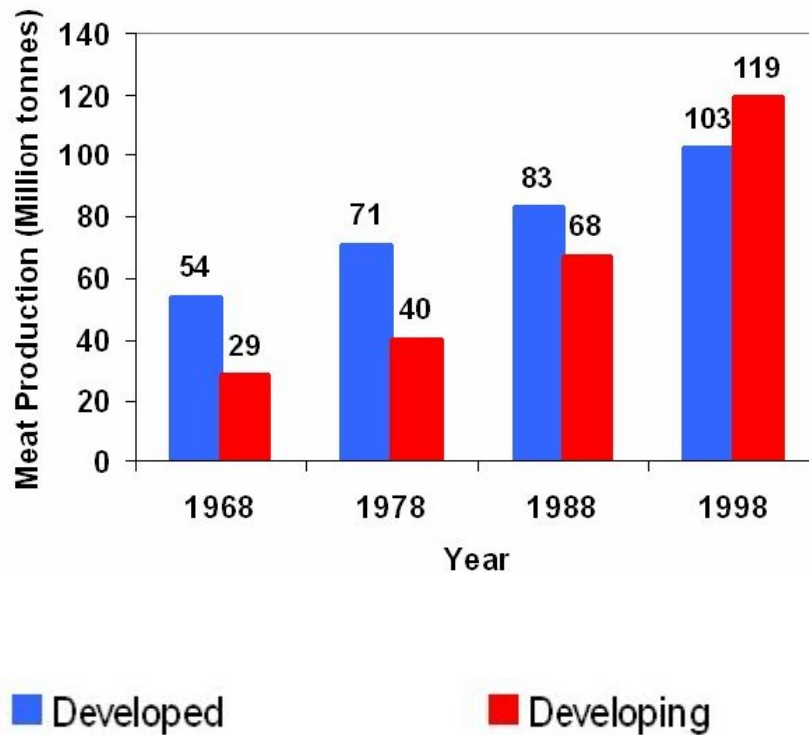
**Figure 2.1** World Population and Projection

Source: United Nations (U.N.) Population Division, Annual Populations 1950-2050 (The 1998 Revision), on diskette (U.N., New York, 1999).



**Figure 2.2** World Cereals Production

Source: FAOSTAT on-line statistical service (FAO, Rome, 1998-99).



**Figure 2.3** World Meat Production (1968-1998)

Source: FAOSTAT on-line statistical service (FAO, Rome, 1998-99)

### **2.3 Livestock Situation in India**

In India about 70% population is engaged in Agriculture. Livestock rearing is complementary to agriculture. Arable agriculture contributes a major fodder resource in the form of crop residues which are extensively fed to the animals. Wheat straw is transported from surplus areas such as Punjab and Haryana to deficit areas, mostly the Himalayan hills. Cultivation of forage crops is restricted to irrigated areas and land rich farmers. Sale of green fodder through retail outlets is a common practice. Cultivation of perennial grasses such as napier and napier X Bajra (*Pennisetum*) hybrids is becoming popular. Intensive fodder cultivation is restricted to States such as Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh and Karnataka. The area cultivated for fodder amounts to 4% of total cultivable area. However, exclusive pastures and grasslands is about 12.4 M.ha or 3.9% of country's geographical area. An area of 15.6 M.ha classified as waste land, is also used for grazing. Forests, and their associated grasslands and fodder trees, are another major source of grazing and fodder collection.

According to 17<sup>th</sup> Livestock Census, the condition of Livestock production in India is shown in Table 2.2.

The Table indicates that the Livestock population varies from State to State and in future the environmental impacts would grow geometrically with arithmetic increase of Livestock.

### **2.4 Livestock Production Systems**

Livestock raising is usually referred to as production systems or agro-ecosystems. Production systems evolve as a result of agro-ecological potential, the relative availability of land, labour and capital and the demand for livestock products. Based on the degree of integration with crops and its relation to land, the world's livestock sector can be classified into three livestock production systems (Sere and Steinfeld, 1996): grazing, mixed farming and industrial systems.

#### **2.4.1 Grazing systems**

Grazing systems are based almost exclusively on livestock production, with little or no integration with crops. They are based mainly on native grassland. In principle, grazing systems are closed systems, where the waste product (manure) is used within the system and does not present a burden on the environment. Resource degradation, especially of land and biodiversity, is now developing in many of the world's grazing areas.

### **2.4.2 Mixed farming systems**

Mixed farming systems are where crops and livestock production are integrated on the same farm. Mixed farming is probably the most benign agricultural production system from an environmental perspective because it is, at least partially, a closed system. The waste products of one enterprise (crop residues), which would otherwise be loaded on to the natural resource base, are used by the other enterprise, which returns its own waste products (manure) back to the first enterprise. It provides opportunities for recycling and organic farming and for a more attractive landscape, mixed farming is the favourite system of many agriculturalists and environmentalists.

### **2.4.3 Industrial systems**

Industrial systems cover industrial types of production and small-scale urban or peri-urban production in developing countries. In recent years, industrial livestock production grew at twice the rate (4.3 percent) of that in mixed farming systems (2.2 percent) and more than six times the grazing system production growth (0.7 percent) . These systems are open both in physical and economic terms. They depend on outside supplies of feed, energy and other inputs. These systems are strongly market driven, which makes them resilient to market upheavals than other systems.

In terms of total production, grazing systems are of lesser importance because they supply only 9 percent of global meat production. Mixed farming systems produce the largest share of total meat (54 percent), and milk (90 percent), and industrial systems provide 37 percent of the total global meat production. Many production systems are currently at a sustainable equilibrium, with livestock being produced in harmony with nature and in environmentally sound systems. However, over the last decades, several

production systems have lost this equilibrium because of the pressure caused by growing human populations and increased demand for animal products (Sere and Steinfeld,1996).

**2.5 Water resources for livestock use**

There are three sources of water for the animal: (1) drinking water (2) water contained in feeds and (3) metabolic water. Water contained in feeds consumed (preformed water) is highly variable from feed to feed according to the moisture content, which can range from as low as 5% in dry feeds to as high as 90% or more in succulent feeds. Water derived from dry feeds may be insignificant compared with the total water intake, while that obtained from succulent feeds can supply all the water needs. Sheep would drink little or no water when the water content of the feed is over 70% ( Sirohi et al. 1997). When water content of the feed ingested is low, drinking water is the major source of water intake, and its provision for livestock becomes the main concern. Most of the water that is utilized by the animal’s body is ingested either as drinking water or as a component of the feed (Woodford et al. 1984).

The oxidation of organic nutrients during metabolic processes in the body leads to the formation of water (metabolic water) from the hydrogen present. On the average fats, carbohydrates and proteins respectively yield 1.07, 0.56 and 0.40 ml water per gram oxidized, or an equivalent of 0.12, 0.14 and 0.10 ml water per kcal metabolisable energy derived from oxidation. For most domestic animals, metabolic water comprises only 5 to 10% of the water intake (Maynard et al. 1981).

Water requirement by livestock appears to be a very individual and specific characteristic. Such differences are reflected in their respective abilities to withstand dehydration and in their demand for free water. As the demand of the individual animal for water is variable, only average estimates of water requirements in a specific climatic environment are generally indicated .Table 2.3 shows the average water requirement by different class of animal.

Table 2.3 Water intake of different class of animals.

Class of Livestock	Daily water requirement(gallons/day)
--------------------	--------------------------------------

Beef cows	7-12
Dairy cows	10-16
Horses	8-12
Swine	3-5
Sheep and Goat	1-4
Note:Extremely hot heat-stress weather could increase the high values another 20 to 30%	

**Source**-Ethiopian Agriculture Research Organisation

The water requirement of domestic animals varies between species, between breeds or varieties within species and between individuals within breeds. For example, heavy western breed cows have a higher water intake (60 to 90 litres/day) than zebu cows (25 litres/day with 350 kg live weight (King 1983). The water demands of sheep, goats and camels are not as high as those of cattle. Water requirement increases with growth, and with increases in productive processes such as lactation and egg laying. Lactating cows consume more water to cope with the water excreted with milk than cows of similar weight fed on maintenance level.

Water requirements also vary according to other factors such as food intake, quality of the food and air and water temperature. Water consumption increases with increasing dry matter intake and increasing temperature. *Bos taurus* cattle weighing 450 kg and eating 10 kg dry feed per day drank 28, 41 and 66 litres of water per day when the temperature is 4, 21 and 32°C, respectively (Maynard et al. 1981). Not only high ambient temperature, but cold weather also influences water intake. Cold weather may reduce water intake.

## **2.6 Environmental Benefits of Livestock Production**

Ball et al., 2002 recognized the soil improvement characteristics of grasslands have long been recognized. After land has been devoted to perennial forages for several years, the trend is for subsequent arable crops to produce better than would otherwise have been the case. The deep root penetration of many forage crops into compacted soil layers can

leave channels that improve water and air movement and enhance root penetration of subsequent crops. Perennial grasslands also tend to make the soil more suitable for subsequent arable crops in other ways, including improving soil tilth due to the activity of earthworms, soil insects, and microorganisms. Over time, the nutrient-holding capacity of the soil increases and various mineral cycles operate to increase nutrient availability in the surface layer.

Compared with other agricultural land uses, growing forage crops greatly decreases erosion. Perennial grass lands are particularly effective in reducing soil erosion losses. Ball et al. (2002) concluded that if the percentage of cropland devoted to forage crops were substantially increased, there would be a considerable improvement in overall water quality. When livestock are produced on pasture and the land is not overgrazed, the likelihood of nutrient contamination of water may be much lower than that of heavily fertilized conventionally produced crops. When land has a thick cover of perennial forages, there is little runoff and therefore less chance for fertilizers to be washed away. Most forage crops, especially perennial grasses, form dense root systems that effectively serve as filters to remove contaminants before they can seep into the groundwater.

## **2.7 Environmental Problems Associated with Livestock Production**

Manure is the primary source of pollution from intensive animal husbandry activities. Chemical constituents of animal manure are given in Table 2.4.

**Table 2.4 Chemical constituents of animal manure**

<b>Chemical</b>	<b>Solid Manure Cattle mg/kg(dry weight basis)</b>	<b>Solid Manure Dairy Cattle mg/kg(dry weight basis)</b>	<b>Solid Manure swine mg/kg(dry weight basis)</b>	<b>Liquid Manure Dairy Cattle Mg/l</b>	<b>Liquid Manure Swine mg/l</b>
Ammonium	3488	13346-14586	2628-4550	165	679-1000
Nitrate	496	-	10-28	1.5	1-2
Chloride	8447	9061	4440	215	300
Total Nitrogen	15800	40037-41436	10600	420	778-1500

**Source**-Minnesota Pollution Control Agency (2001)

Nutrients (particularly nitrogen and phosphorus), organic matter, solids, pathogens, and odorous/volatile compounds are the primary pollutants derived from animal waste. Manure is also a source of salts and trace elements, and to a lesser extent, antibiotics, pesticides, and hormones. The particular composition of manure will depend on the particular species (cattle, pigs or poultry), the animal's size, maturity, and health, as well as the constituents of the animal feed. The environmental effects will relate to the scale and type of operation and the wastewater management practices in place.

### **2.7.1 Sediment**

Water quality of streams, lakes, or other water bodies may be degraded by excessive amounts of dissolved or suspended sediment in surface runoff or base flows. Numerous studies have been reported on sediment concentrations and loads for a variety of drainage systems ( McGuinness et al., 1971; Griffiths, 1982; Neff, 1982; Carling, 1983), along with information relating loads to rainfall intensity and duration, runoff amount, drainage area, or land use ( Dendy and Bolton, 1976; Costa, 1977; Ostry, 1982). Heavy loads of suspended sediment in stream flow can reflect erosion from grazed pastures with poor forage stands and heavy traffic from grazing animals.

It has been recognized that for over 90 yr, heavy, continuous grazing accelerates erosion and runoff . The literature is filled with examples of the adverse impacts of overgrazing on watersheds ( Smeins, 1975; Dregne, 1978; Crouch, 1979).

### **2.7.2 Nitrogen**

The compound form of N of primary concern is  $\text{NO}_3$  nitrogen. Nitrate movement into surface and ground waters is of concern both for health and environmental quality reasons. Nitrate concentrations in excess of 10 mg/L cause methemoglobinemia, which is toxic to infants (Federal Register,1975). Most cases of methemoglobinemia occur after consuming water with high concentrations of  $\text{NO}_3$  nitrogen. Infants are particularly susceptible, as are people who receive kidney dialysis treatment .

Other effects associated with elevated concentrations of  $\text{NO}_3$  nitrogen in drinking water include respiratory infection, alteration of thyroid metabolism, and cancers induced by conversion of  $\text{NO}_3$  nitrogen to N-nitroso compounds in the body (Follett and Follett, 2001).

Eutrophication of lakes or other water bodies occurs when excess plant or algal growth takes place. Nitrogen may be a limiting nutrient to growth of these species, and hence excess  $\text{NO}_3$  nitrogen levels entering streams or lakes with surface runoff or by shallow subsurface flow may cause environmental quality problems.

Nitrogen exists in soil as  $\text{NO}_2$ ,  $\text{NO}_3$ , or  $\text{NH}_4$  nitrogen, or in organic forms within the soil organic matter fraction. Nitrate ions are repelled by the clay particles in the soil and generally are not absorbed within the soil matrix. Hence, as water moves through the soil,  $\text{NO}_3$  nitrogen generally moves freely with the water. The actual movement of  $\text{NO}_3$  nitrogen through soil lags behind the wetting front due to mixing processes such as diffusion and hydrodynamic dispersion, which occur between the resident soil solution and the infiltrating water from irrigation or rainfall.

Numerous studies have documented  $\text{NO}_3$  nitrogen concentrations greater than 10 mg/L in groundwater associated with agricultural activities including cropping enterprises, livestock, and grazing (Spalding and Exner, 1980; Hubbard et al., 1986, 1987; Naney et al., 1987; Sharpley et al., 1987; Hubbard and Sheridan, 1989, 1994).

Nitrate contamination of groundwater can also occur in urban areas from septic tanks or over fertilization of lawns (Hubbard and Sheridan, 1994).

Nitrogen from the urine and feces of grazing animals can negatively affect water quality when the number of grazing animals per land area exceeds the N fertility needs of the forages. Campbell et al. (1977) compared standard beef cattle pasture stocking rate with double pasture stocking rate, confinement and a natural area and found that  $\text{NO}_3$  nitrogen concentrations in shallow groundwater wells at 1.2 m increased at the double stocking rate compared with the other treatments.

### **2.7.3 Phosphorus**

Phosphorus is of environmental concern because excess amounts in surface water bodies cause eutrophication. Phosphate is a soluble agricultural chemical that may be moved from point of application by surface runoff or move out of the soil surface layer with percolation. In general,  $\text{PO}_4$  is considered to be of concern primarily for surface runoff since it binds to Fe, Al, or Ca in the soil depending on pH and is not readily leachable. Soluble  $\text{PO}_4$  and  $\text{PO}_4$  associated with sediment in surface runoff have been found to vary linearly with P application rate (Romkens and Nelson, 1974).

Movement of  $\text{PO}_4$  through the soil profile varies with soil texture. For nonsandy soils, the leaching of  $\text{PO}_4$  with percolating water is extremely low or undetectable. The  $\text{PO}_4$  content of percolate from non sandy soils can be within an order of magnitude of 0.1 mg/L (Russell, 1961).

Numerous investigators (Russell, 1960; Bolton and Coulter, 1996) have shown that in very sandy soils,  $\text{PO}_4$  will move down the profile to a considerable depth (>1.0 m).

On the basis of diffusion studies, Olsen and Watanabe (1970) concluded that there was an eight-times-greater risk of  $\text{PO}_4$  pollution of ground water from sands than from clays.

The contribution of P from animal wastes can under some circumstances represent a significant fraction of the P circulating in agricultural systems. Where fecal matter is deposited into farm ponds or streams the direct effect may be noticeable. Most severe P problems related to animal wastes may arise where there are local, high density animal populations in feedlots, barnyards, or pastures close to streams (Schepers and Francis,

1982; Schepers et al., 1982; Fisher et al., 2000). Actual losses will depend upon management practices.

.Chichester et al. (1979) showed that concentrations of P in runoff were not increased by summer grazing of pasture in Ohio, but where animals were pastured throughout the year, winter damage to the soil surface (trampling from hooves damaging vegetation and causing soil compaction) caused both increased runoff and nutrient discharge.

#### **2.7.4 Pathogens**

Water quality in many lakes and rivers has been impaired by the presence of high levels of fecal coliform, which is indicative of contamination by feces (Jones and Roworth, 1996; Ackman et al., 1997). Such contamination brings the threat of infection for people who use the water for drinking, bathing, or watering fruits and vegetables. Underlying this concern are numerous reports of waterborne outbreaks of disease involving fecal organisms such as *Escherichia coli* O157:H7, *Campylobacter jejuni*, *Salmonella* species, *Vibrio cholerae*, and shigellae (Jones and Roworth, 1996; Gugnani, 1999; Licence et al., 2001).

Other bacterial infections that can be transmitted in water from animal to animal and from animal to human include *Listeria*, *Leptospira*, *Brucella*, *Coxiella*, and *Mycoplasma* (Hensler et al. 1970; Young 1974; Hatfield et al., 1998). Nonbacterial infectious agents that can be transmitted in water include fungi and protozoa (*Cryptosporidium*).

It is also important to determine whether the source of fecal contamination is of human, livestock, or wildlife origin, as microorganisms of human origin are regarded as having greater potential to cause disease in humans (Puech et al., 2001).

Wright,1998 focusses *Cryptosporidium parvum*, a widespread protozoan parasite afflicting animals and humans. The dominant mode of transmission of *C. parvum* to humans is believed to be via contaminated drinking water and recreational waters. Zoonosis is the term used to describe infections crossing hosts, such as the case with *C. parvum*. Although no clear-cut epidemiological cause and effect has been established, it is widely believed that farm animals are the predominant source of *C. parvum*.

Dairy farms are particularly suspect as potential sources of *C. parvum* because newborn calves are readily infected and excrete large numbers of the infectious stage (oocyst) of this organism. Table 2.5 shows the possible diseases to humans with the type of Livestock association.

**Table 2.5 Diseases to Humans with the type of Livestock Association.**

Livestock Type	Disease
Cattle	Brucellosis, Q fever
Cattle, Horse	Anthrax
Poultry	Salmonellosis
Rabbits	Tularemia
Left over feed from cattle	Actinomycosis
Pigeons, Parrots	Parrot fever
Cows infected with meat	Mad cow
Pork	Trichinosis

**Source-**Municipal and Rural Sanitation by Ehler & Steel, Mc Graw Hill, New York

### **2.7.5 Oxygen-demanding Waste**

Manure from grazing animals contains organic matter, which can serve as oxygen-demanding materials (Hatfield et al., 1998). Organic matter serves as an energy source for aerobic bacteria in a receiving stream or lake. Increased bacterial metabolism resulting from a discharge of organic waste into a water body increases the oxygen depletion rate of the water. If the rate of oxygen depletion exceeds the aeration rate of the stream, oxygen depletion occurs. Decreased oxygen levels can result in fish kills and anaerobic conditions in the stream or other water body.

The parameters for expressing organic matter are BOD and COD. Chemical oxygen demand will exceed the BOD demand value for animal wastes, since animal manure and other waste products contain organic materials resistant to aerobic bacterial degradation. Chemical oxygen demand/BOD demand ratios vary from 3.5 to 6.5 depending on species and feed rations (Hatfield et al., 1998).

From the discussion made above, its clear that the thought of Groundwater purer than Surface water is not valid today. Several sources i.e. natural and artificial are involved in contaminating Groundwater. Unlike Surface water, groundwater once receives pollution it is practically difficult to remediate it.

The measures to control the Groundwater pollution is-

- Maintain minimum distance of well from Source of pollution
  1. 50 m from storage area of fertilizer,chemicals
  2. 22.9 m from cesspools
  3. 15 m from Septic tanks
- Top of the well to be covered to prevent entry of surface water.(ground to slope away from the well)
- The washing near the well should not be allowed
- The pumping rate from the well should not be excessive.
- No trees should be grown near the well
- The casing should extend by about 3 m.below the water table
- The priming of pump should not be carried out by using contaminated water
- Pump house should be adequately drained and protected against flooding
- Pump should not be installed below ground in pits
- Connection between casing and pumping unit should be water tight
- Wells should be provided with enough vents so as to prevent the suction of contaminated water into the wells.

## CHAPTER: 3 MATERIALS AND METHODS

This chapter discusses the materials used and techniques followed during the study.

- Chemicals-Chemical used were of analytical grade with purity.
- Instruments-all instruments with accuracy procured from authorized dealers were employed for measurement of sample characteristics.
- Calibration Curves-They were prepared from Stock solutions, before estimating the unknown parameters (N, P etc) and were used throughout the study.

### 3.1 Selection of Animal Farms

A preliminary survey was made in and around Patiala for 15 days and observed for animal farms where sufficient number of animals are maintained on continuous basis, soil quality allows waste seepages into ground and facility for collection of ground water sample is present. The advise of owners of animal farms was also considered in the final selection of the sites. Table 3.1 shows the features of animal farms selected during the study.

**Table 3.1 Features of animal farms selected for study**

<b>Serial Number</b>	<b>Location</b>	<b>Numbers of Animals</b>	<b>Water Depth(ft)</b>
1	Model Town	65-70	70
2	Ablowal Village (Practice of intense agriculture)	50	70-80
3	Bharat Nagar (A)	50	80
4	Bharat Nagar (B)	60	80

- Dairy farm at Rajpura (containing 380 animals) owned by Coca-cola company. Here the water table was 80-85 ft, was selected for Ground Water monitoring onced.

## **3.2 Water Sample Collection**

Ground water at the animal farms selected earlier were monitored every month. The study was conducted between September 2005 to April 2006, with the exception November due to technical reasons, covering monsoon, winter, presummer seasons.

Grab samples of Ground water were collected (approved containers) at animal farms by pumping water through submersible pumps (pumps were found within premises of animal farms, except at the dairy farm of Rajpura which was at 50 m. distance). Care was given by sufficiently pumping and wasting of water before the collection of Representative Sample. The procedure followed was as suggested in Standard Methods.

With a view to confirm the results obtained, water samples were also collected at control points from Hand Pumps. These were located at distances of 0.05 to 1.0 Km. from the animal farms individually, except at Dairy farm of Rajpura which was 3 Km. away.

## **3.3 Parameters of Study and Procedures for Water Samples Analysis**

### **3.3.1 Physical Parameters**

#### **pH**

The pH was measured by electronic pH meter(digital pH meter 5652). PH of water samples was determined , after calibrating the pH meter with buffer solutions of pH 4.0, 7.0, and 9.2. (4500- $H^+$  .B of Standard Method)

#### **Turbidity**

Turbidity of a sample was measured by Nephelometer by using optical properties of light. (2130 .B of Standard Method)

#### **Conductivity**

Conductivity is measured with the help of a conductivity meter. (2510.B of Standard methods)

### **3.3.2 Chemical Parameters**

#### **Chloride (Cl<sup>-</sup>)**

Argentometric volumetric titration method in the presence of Potassium chromate provides reliable results of  $\text{Cl}^-$ . (*4500-Cl<sup>-</sup>.B of Standard Methods*)

50 ml of water sample is taken and few drop of Methyl orange indicator is *Alkalinity* added in the sample and titrated with 0.02 N  $\text{H}_2\text{SO}_4$  till the colour get changed from yellow to orange. (*2320.B of Standard Methods*)

### **Total Hardness**

EDTA titration method with presence of EBT indicator was adopted. (*NEERI, 1981*)

### **Ca Hardness**

Sample titration with EDTA in presence of murexide indicator was the method. (*NEERI, 1981*)

### **Mg Hardness**

It's the difference between total hardness and Ca hardness. (*NEERI, 1981*)

### **Nitrite**

50 ml of water sample is taken and 1 ml of NEDA (naphthyl ethylene diamine dihydrochloride) is added as a colouring agent and absorbance was taken at 543nm. (*4500-NO<sub>2</sub>. B of Standard Methods*).

### **Nitrate**

It is estimated through colourimetric method by passing water sample through cadmium-Copper column and absorbance is taken at 543 nm. (*4500-NO<sub>3</sub>. E of standard Methods*).

### **Ammonical Nitrogen (Titrimetric Method)**

Distillation of sample for  $\text{NH}_3$  and titration with mixed indicator was adopted. (*4500-NH<sub>3</sub>. C of Standard Methods*)

### **Organic Nitrogen**

Digestion of sample followed by distillation and titration as above measures organic nitrogen. (*4500-N<sub>org</sub>. B of Standard Methods*)

Sample digestion with Nitric acid-Perchloric acid followed by *Total Phosphorus* measurement of red colour at 690 nm.with addition of  $\text{SnCl}_2$  is the

method adopted. (4500-P . B of Standard Methods)

### **Chemical Oxygen Demand (COD)**

Closed refluxion of sample followed by titration with FAS was adopted. (5220C of Standard Method)

### **Biological Oxidation Demand (BOD)**

The method of Winkler was used for estimating initial and final D.O. in the sample and BOD was calculated. (5210B of Standard Method)

## **3.2.3 Biological Parameters**

### **Total and Fecal Coliform**

Total and Fecal coliform were tested at the ratios of sample 10:1:1:01 with Mac-conky broth and A-1medium respectively. Sample of Total Coliform was incubated at 370C for 24 hours and Fecal Coliform at 44 0C for 48 hours .Noting down the number of positives tubes from each set and referring to the standard tables gave the bacterial count.(9221.B and 9230.B of Standard Methods)

### **3.4 Parameters of Study and Procedures for Soil sample**

#### **3.4.1 Physical Analysis**

##### **Soil Permeability**

It is used to determine the coefficient of permeability of the soil. First the mould with dummy plate was weighed. Then measured the internal diameter and effective height of the mould. Then the soil was compacted at known dry density and moisture content. The weight of the mould with soil and dummy plate was taken again and placed it on the base plate. The filter paper and washer were placed on the top of the soil sample and fixed up the collar. The reservoir with water was connected to the outlet at the bottom of the mould and allowed the water to flow in. Waited till the water has been able to travel up and saturate the sample. After saturation disconnected the reservoir from the outlet at the bottom and connected to the inlet at the top plate. Opened stop cock at cover and allowed water to flow out so that all air in the cylinder is removed. When all the air has escaped, closed the stopcock and opened the outlet and allowed the water to flow through the soil and established the steady flow. When steady flow was reached collected the water in a measuring flask for convenient time interval. (*Soil Testing Manual*)

##### **Compaction Test**

This test was done to determine the optimum moisture content and dry density of soil. Taken 2.5 kg of sieved soil for 1000 cc mould. Added water to it to bring its moisture content to about 4% in coarse grained soil and 8% in fine grained soil. Cleaned, dried and greased tightly the mould and base plate. Weighed the mould with base plate. Filled the collar and placed the mould on solid base. Compacted the wet soil in 3 equal layers by the rammer of mass 2.6 Kg. Removed the collar and trim off the soil flush with top of the mould. Clean the outside of mould and base plate, weighed the mould with soil and base plate. Removed the soil from the mould and obtained the representative soil sample from the bottom, middle and top for water content determination. Weighed the drying crucible with samples and put it in the dry oven at temperature 105<sup>0</sup>C for 24 hours. Next day, weighed the crucible with dry soil sample and then the empty crucible. This procedure

was repeated with 10%,12%,14%,16%,18% of water content till the optimum moisture was not reached. (*Soil Testing Manual*)

### **Water Holding Capacity**

The soil sample was collected, crushed and dried at 105<sup>0</sup>C. The perforated moisture box with filter paper was weighed. Added enough soil again weighed it. Removed the boxes from water and kept on filter paper and then after 5 minutes dried it in an oven at 1050C for constant weight. (*Rajor, 2006*)

## **3.4.2 Chemical analysis of Soil sample**

### **Total Phosphorus**

1 gm of soil was dissolved in 100 ml of distilled water and digestion with Nitric acid-Perchloric acid digestion method. Stannous chloride method was followed for colour development. (*4500-P.B of Standard Method*)

### **Total Nitrogen**

Taken 2 gm of soil sample and 1 gm salicylic acid in kjeldahl flask. Added 20 ml of H<sub>2</sub>SO<sub>4</sub> and left for half and hour for pre digestion. Then added .5 gm. Sodium thio sulphate and 2 gm of digestion mixture and digested the samples by heating till the colour changes to light green. Cool the sample and made the volume to 300 ml with Distilled water.

Transferred digested sample into the distillation flask and added 25 ml of 40% NaOH. Absorbed the evolved ammonia in 50 ml of Boric acid till 200 ml of distillate was collected. Titrate against .02 H<sub>2</sub>SO<sub>4</sub> and note the volume of H<sub>2</sub>SO<sub>4</sub> used to change the colour from green to Violet. (*Singh, D., et al., 1999*)

### **Nitrate and Nitrite**

Nitrate and nitrite are extracted by shaking 3 g of air-dried soil in 30 mL 0.01 M CaSO<sub>4</sub> for 5 minutes and then filtered. The nitrate in the filtrate is measured colorimetrically on an Alpkem Rapid Flow Analyzer at 520 nm. In this method, the nitrate is reduced to nitrite in a copperized cadmium column. The nitrite then reacts with sulfanilamide under

acidic conditions to form a diazo compound. This in turn couples with N-1-Napthylethylenediamine dihydrochloride to form a reddish purple azo dye. Nitrite is determined by the same process but without using the copperized cadmium column. (*Rajor, 2006*)

#### **Organic Matter(Titrimetric method)**

1 gm.of soil sample was taken and added 10 ml of  $K_2Cr_2O_7$  solution and 20 ml concentrated  $H_2SO_4$ . Allowed the flask to stand undisturbed for 30 minutes followed by addition of 200 ml distilled water. Added 10 ml of Ortho phosphoric acid and 0.5 gm. of NaF. Titrated with .05 N FAS till colour changed from blue-voilet to green. (*Rajor, 2006*)

### **3.4.3 Biological Analysis of Soil Samples**

#### **Soil Microorganism**

Bacterial count number in soil samples was estimated by spread plate method. (*9215 C of Standard Method*)

## **CHAPTER: 4 RESULTS AND DISCUSSION**

The chapter presents results of the study conducted and discussion on results.

### **4.1 Animal farms and Surroundings**

All the animal farms in question had numbers of animals varying from 50 to 380. The animals were maintained on continuous basis. The left over feed and the solid dungs were dumped as heap very near to the farms. Liberation of odours and fly menance was seen clearly near the dump. The solid dung was later made to briquettes, dried and used for burning.

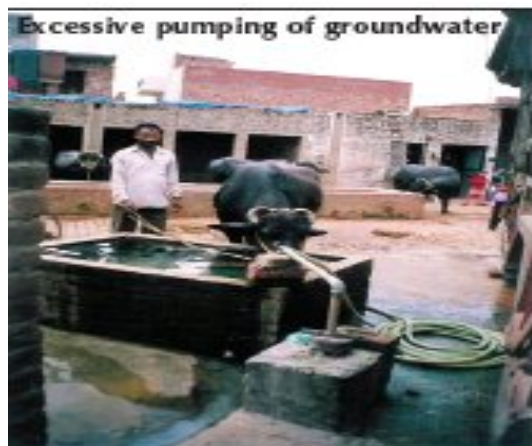
The facility for collection of liquid waste (cattle urine) was non existent and liquid was entering and soaking into soil near the animal farms.

The owner of the farms were found withdrawing water through submersible pumps and using it for drinking and feeding to animals. Surprisingly the pumps were located within the premises of the farms or at a maximum distance of 50m.

The water table at the farms 70-85ft represented the shallow water table.

No other significant activity was found in the vicinities of the animal farms, hence it was presumed that the Ground water quality here was majorly due to the selected animal farms.

The animal farms are major sources of Ground water pollution in an agrarian country like India. Although tube wells are better source than open wells, being shallow they can easily receive contamination and hence affects the health of city dwellers. Fig 4.1 shows an animal farm and location of water withdrawal adjescent to it.



*Fig 4.1 Animal Farms and Location of water withdrawal*

## **4.2 Results of characteristics of water samples**

The water quality contaminants of concern from animal farms are Sediment (erosion), N, P, Pathogens and Organic matter. Animals negatively affect water quality when the number of animals exceeds the carrying capacity of the land.

The test samples at animal farms and at control points are represented from Table 4.1 to 4.7 and Fig 4.2 to 4.15. The samplings of Sep. 2005, Oct. 2005, Dec. 2005, Jan. 2006, Feb. 2006, March 2006 and April 2006 represented monsoons, winter and pre-summer seasons respectively.

Physical and chemical parameters such as Turbidity, BOD, COD, Nitrogen forms, Phosphorus, Hardness and Biological characteristics such as Total and Fecal coliforms are presented in tables.

**pH** of water at all stations was almost neutral. According to W.H.O. low pH is likely to give rise to off taste and to promote corrosion. The limit is 6.5 to 8.5. So all the samples are under limit.

**Conductivity** measures the electrical current, which is proportional to the mineral present in the water. Generally if conductivity is higher in Groundwater, this indicates the proportion of dissolved solid in it. From the results it shows that maximum conductivity was found in Model Town and minimum in Bharat Nagar(B). This pattern is constant through out the study.

**Turbidity** of all the samples ranges between 0.441 to 0.225 NTU .

The **Organic matter** is represented by BOD and COD. The maximum COD values were observed to be 43 mg/l though BOD values is 1.8 mg/l. The low values of BOD clearly indicates the low level of biodegradable materials and absence of non-biodegradable substances. Usually drinking water has a BOD value less than 1 mg/l and water is fairly pure if BOD is 3 mg/l and doubtful purity is at 5 mg/l. From above data it is observed that all samples are not polluted by organic matter (Indrabai and Seenamma, 2002). COD of Groundwater polluted with animal wastes is often found higher than BOD because animal manure and other waste products contains organic materials resistant to aerobic degradation (Hatfield et al,1998). This supports the results shown in tables.

**Hardness** was quite significant in the sample analyzed and optimum values were observed at all stations throughout the study. Hardness of ground water is majorly the temporary due to bicarbonate of Ca and Mg. This indicates the difficulty in cleaning utensils and washing clothes. The total hardness value ranges between 232 to 380 mg/l and they are well below the maximum permissible limit. Magnesium tolerance by human body are lower than that of Calcium and the high concentration work as laxative and give unpleasant taste to the water as Mg ion. It also adds to hardness. The concentration of Mg in groundwater of all sites ranges from 232 to 380mg/l. The Calcium hardness is 128 to 244 mg/l. Calcium as an ion is one of the principal cation in ground water. As Calcium the human body requires 0.7 to 2.0 gm/day as it is the most abundant element in human body. Hard water contains Calcium and Magnesium ions. It is generally defined as the Calcium carbonate scale equivalent of Calcium and Magnesium.

The **Compound of Nitrogen** of primary concern is  $\text{NO}_3$  nitrogen. Nitrate movement into surface and ground water is concern of both for Health and Environmental quality reasons (Galloway et al, 2003). In the results nitrate ranges between 0.047 to 0.264 mg/l in all the stations in September 2005 to April 2006, these results indicates that  $\text{NO}_3^-$  is low in all the samples and are below the permissible limit. Similar findings were reported by Singh et al,1999. The Nitrate concentration in excess of 10 mg/l cause Methemoglobinemia, which is toxic to infants. Nitrate in ground water may generally be due to oxidation of organic nitrogenous substances and due to sewage disposal. Other

forms of Nitrogen is  $\text{NO}_2$  which is considered to be carcinogenic. Nitrite in all the tasted samples was found in the range of 0.118 mg/l to 0.012 mg/l which is not harmful to health.

**Ammonical nitrogen** was found in the range of 0.672 to 0.280 mg/l. Highest concentration was found in the month of September in Bharat Nagar (A) sample.

**Organic Nitrogen** was found in the range of 1.68 to 0.392 mg/l. Highest organic nitrogen content was found in the month of September in Ablowal sample and lowest in Bharat Nagar (B) sample in January.

**Total Phosphorus** ranges between 0.068 to 0.033 mg/l. The excess phosphate may lead to Eutrophication, but due to relatively very low concentration no possibility of eutrophication.

**Alkalinity** in water is due to the presence of carbonates, bicarbonates and hydroxide. These constituents results from dissolution of mineral substances in the soil and atmosphere (Mittal and Verma,1997). The alkalinity of water sample fall in the range of 246-394 which is in the permissible limit.

**Chloride** in the form of  $\text{Cl}^-$  ion is one of the major inorganic ion in the water. Chloride was found in the range of 0.02 to 0.48 mg/l which is very low and under the permissible limit.

Considering the **coliforms**, most of the water samples showed presence, both total and fecal type. Presence of fecal coliform in Groundwater samples indicate the possible contamination due to animal farms.

The water quality impaired by the presence of high level of fecal coliform bacteria. Licence et al, 2001 observe water born diseases in which fecal organism involves. When surface runoff or leaching occurs due to excessive irrigation or rainfall or animal urine etc. contamination of water resources by enteric bacteria may results (Entry et al, 1999)

Hubbard et al, 2003 shows that Grazing animals and pasture production can negatively affect water quality through erosion and sediment transport into surface waters, through nutrients from urine and feces dropped by the animals and fertility practices associated with production of high quality pasture, and through pathogens from the wastes.

One sample was collected from dairy situated on Rajpura road. They are having 380 numbers of cows and covering large land area. The result was shown in table no. 4.8. The water sample of this area is free of contamination on the point of view of Physical and Chemical parameter. In biological test even in control sample which is 3 km way from the site is having 15 MPN/100 ml Total coliform and 9 MPN/100 ml Fecal coliform which indicates that water is contaminated in Bacteriological point of view.

### **4.3 Water Quality – Spatial Distribution**

Quality of Ground water varied from station to station.(Hardness values are 280,350,270 & 270 mg/l as CaCO<sub>3</sub> at sampled stations for April 2006).This depends on number of animals, quality of soil and local water table.

Highly polluted Ground water indicates the possible health risk to people and the type of water treatment necessary.

My observation of results indicated that Ground water pollution was more at Model Town then at another stations. Wagh and Srivastava, 2006 has shown the statistical approach of ground water contamination by municipal sewage. The results revealed that the sewage water deteriorates the water quality and more correlation coefficient was observed when sample taken near to sewage effluent point

### **4.4 Water Quality- Temporal Distribution**

Ground water quality varied from season to season at sampled locations. Samples collected showed high concentration of contamination in rainy season whereas it was less in pre-summer. (Total coliform are 93/100 ml in Sep. 2005 and 9/100 ml in April 2006 at Ablowal station). Most of the quality parameters exhibited the same trend.

Rainy season contributes more leached water thus raising the water tables. Hence with ease of pollution, the detrimental effects on population is severe. In summer the leaching is small, and before joining the water table, it may exhaust during the journey through the soil.

#### **4.5 Water Quality –Test station and Control station**

To find out the influence of animal farms in surroundings, control stations were selected and Ground water quality was assessed. It was observed that the animal farms were not significant in deteriorating the quality at control points (Total coliforms is 23/100 ml and 9/100 ml at test station and control station respectively in March 2006 at Model Town). The only activity at the control station was residential.

Ground water is not static but slowly moves in the lateral direction. When three Groundwater elevations at a place are known, local Ground water contours and direction of Ground water through aquifer can be estimated.

#### **4.6 Graphical representation-Water Quality Parameters**

The significant deterioration of Ground water occurs through nutrients (forms of Nitrogen and Phosphorus) or Pathogens (coliforms etc).

The level of Nitrates was higher than Nitrites in analyzed samples. Nitrate represents the stable form and nitrite, the unstable forms.

Pathogens, as indicated by total and fecal, are objectionable and the presence of which makes water, unfit for drinking. The role of Nutrients and pathogens are discussed by Follett and Follett, 2001 and Puech et al, 2001 respectively.

#### **4.7 Soil Analysis**

The results of soil analysis are shown in Table 4.9.

The water holding capacity varied from 8% to 13% and the type of soil from Clay to Sand. Livy et al,1999 reveals that prolong use of waste water may increase the pH, organic carbon, phosphate but decrease water holding capacity. Soil analysis showed a good amount of nutrients (5.6 to 9.8 mg/100 g TKN, 7.4 to 15.5 mg/100g  $\text{NO}_3^-$  and 6.87 to 9.8 mg/100 g  $\text{PO}_4^{-3}$ ). The nitrogen exists in the soil as  $\text{NO}_2$ ,  $\text{NO}_3$  or  $\text{NH}_4$  nitrogen, or in organic forms within the soil organic matter fraction. Nitrate ions are repelled by the clay particles in the soil and generally are not absorbed within the soil matrix. The water moves freely through the soil as well  $\text{NO}_3$  also moves freely with the water (Hubbard et

al, 2003). Movement of Phosphate through the soil profile varies with soil texture. For non sandy soils, the leaching of  $\text{PO}_4$  with percolating water is extremely low or undetectable. The organic matter from 20% to 30% provided a support of soil for deciding soil characteristics and growth of microbial flora.

The soil microorganisms varies from  $29 \times 10^{-3}$  to  $80 \times 10^{-8}$  which shows that soil is rich in microorganisms due to animal operations such as grazing (Guan and Holley 2003).

Sandy soil has more permeability allowing more water to transmit into the ground. Clayey soil are rich in porosity, the ability to support the storage of water.

Although much effort was not made to correlate the property of soil with Ground water quality studied, it is certain that soil characteristics influenced Groundwater Pollution.

Russel 1961, Olsen and Watanabe 1970 concluded that there is a greater risk of Ground water pollution due to sands than clays.

**Table 4.1 Water Samples Analysis in September 2005**

<b>Parameters</b>	<b>Samples</b>			
	<b>Model Town</b>	<b>Ablowal</b>	<b>Bharat Nagar(A)</b>	<b>Bharat Nagar(B)</b>
pH	7.42	7.51	7.37	7.42
Conductivity (m. mho/cm)	0.897	0.717	0.576	0.539
Turbidity(NTU)	0.385	0.317.	0.425	0.415
BOD(mg/l)	1.1	.90	0.90	1.3
COD(mg/l)	43	35	32.5	25
Alkalinity(mg/l as CaCO <sub>3</sub> )	394	318	256	256
Chloride(mg/l)	0.46	0.48	0.30	0.12
Nitrate(mg/l)	0.137	0.126	0.120	0.119
Nitrite(mg/l)	0.105	0.025	0.118	0.022
Total Phosphorus (mg/l)	0.056	0.068	0.048	0.040
Ammonical Nitrogen(mg/l)	0.56	0.616	0.672	0.56
Organic Nitrogen(mg/l)	1.12	1.68	1.12	0.896
Total Hardness(mg/l as CaCO <sub>3</sub> )	286	380	270	260
Calcium Hardness(mg/l as CaCO <sub>3</sub> )	164	226	154	144
Magnesium Hardness (mg/l as CaCO <sub>3</sub> )	122	154	116	116
Total Coliform (MPN/100 ml)	460	93	93	43
Fecal Coliform (MPN/100 ml)	240	43	43	23

**Table 4.2 Water Samples Analysis in October 2005**

Parameters	Samples			
	Model Town	Ablowal	Bharat Nagar(A)	Bharat Nagar(B)
pH	7.30	7.41	7.40	7.38
Conductivity(m. mho/cm)	0.872	0.691	0.517	0.498
Turbidity(NTU)	0.347	0.286	0.441	0.392
BOD(mg/l)	1.0	0.9	1.0	1.2
COD(mg/l)	40	37.5	30	27.5
Alkalinity(mg/l as CaCO <sub>3</sub> )	382	312	260	248
Chloride(mg/l)	0.40	0.44	0.26	0.08
Nitrate(mg/l)	0.127	0.112	0.100	0.098
Nitrite(mg/l)	0.099	0.032	0.090	0.019
Total Phosphorus (mg/l)	0.048	0.065	0.045	0.042
Ammonical Nitrogen(mg/l)	0.504	0.448	0.56	0.504
Organic Nitrogen(mg/l)	1.064	1.40	0.84	0.56
Total Hardness(mg/l as CaCO <sub>3</sub> )	290	380	260	266
Calcium Hardness(mg/l as CaCO <sub>3</sub> )	158	244	168	156
Magnesium Hardness(mg/l as CaCO <sub>3</sub> )	132	136	92	110
Total Coliform (MPN/100 ml)	240	93	93	93
Fecal Coliform (MPN/100 ml)	93	43	43	23

**Table 4.3 Water Samples Analysis in December 2005**

Parameters	Samples			
	Model Town	Ablowal	Bharat Nagar(A)	Bharat Nagar(B)
pH	7.36	7.52	7.47	7.32
Conductivity(m. mho/cm)	0.796	0.682	0.431	0.452
Turbidity(NTU)	0.321	0.297	0.387	0.415
BOD(mg/l)	1.1	1.0	1.5	1.2
COD(mg/l)	37.5	32.5	27.5	20
Alkalinity(mg/l as CaCO <sub>3</sub> )	388	320	246	252
Chloride(mg/l)	0.36	0.38	0.20	0.02
Nitrate(mg/l)	0.108	0.118	0.081	0.095
Nitrite(mg/l)	0.091	0.030	0.090	0.012
Total Phosphorus (mg/l)	0.051	0.058	0.039	0.042
Ammonical Nitrogen(mg/l)	0.392	0.448	0.392	0.336
Organic Nitrogen(mg/l)	1.064	1.4	0.84	0.56
Total Hardness(mg/l as CaCO <sub>3</sub> )	278	372	248	256
Calcium Hardness (mg/l as CaCO <sub>3</sub> )	140	224	150	142
Magnesium Hardness (mg/l as CaCO <sub>3</sub> )	138	148	98	114
Total Coliform (MPN/100 ml)	240	93	93	43
Fecal Coliform (MPN/100 ml)	93	43	23	23

**Table 4.4 Water Samples Analysis in January 2006**

Parameters	Samples			
	Model Town	Ablowal	Bharat Nagar(A)	Bharat Nagar(B)
pH	7.30	7.36	7.42	7.28
Conductivity (m. mho/cm)	0.739	0.651	0.476	0.437
Turbidity(NTU)	0.287	0.252	0.390	0.379
BOD(mg/l)	1.3	1.8	1.5	1.2
COD(mg/l)	35	30	22.5	15
Alkalinity(mg/l as CaCO <sub>3</sub> )	382	312	258	252
Chloride(mg/l)	0.38	0.32	0.16	0.04
Nitrate(mg/l)	0.107	0.133	0.074	0.088
Nitrite(mg/l)	0.080	0.020	0.076	0.015
Total Phosphorus (mg/l)	0.040	0.062	0.045	0.038
Ammonical Nitrogen(mg/l)	0.336	0.336	0.392	0.336
Organic Nitrogen(mg/l)	0.952	1.232	0.728	0.392
Total Hardness(mg/l as CaCO <sub>3</sub> )	274	354	264	274
Calcium Hardness(mg/l as CaCO <sub>3</sub> )	152	212	148	152
Magnesium Hardness(mg/l as CaCO <sub>3</sub> )	122	142	116	122
Total Coliform(MPN/100 ml)	93	43	43	93
Fecal Coliform(MPN/100 ml)	43	23	15	43

**Table 4.5 Water Samples Analysis in February 2006**

<b>Parameters</b>	<b>Samples</b>			
	<b>Model Town</b>	<b>Ablowal</b>	<b>Bharat Nagar(A)</b>	<b>Bharat Nagar(B)</b>
pH	7.37	7.41	7.57	7.32
Conductivity (m. mho/cm)	0.717	0.646	0.491	0.458
Turbidity(NTU)	0.256	0.249	0.372	0.385
BOD(mg/l)	1.8	1.3	1.6	1.2
COD(mg/l)	35	27.5	22.5	20
Alkalinity(mg/l as CaCO <sub>3</sub> )	394	332	248	254
Chloride(mg/l)	0.34	0.36	0.20	0.02
Nitrate(mg/l)	0.148	0.148	0.096	0.264
Nitrite(mg/l)	0.071	0.027	0.082	0.023
Total Phosphorus (mg/l)	0.045	0.057	0.048	0.040
Ammonical Nitrogen(mg/l)	0.392	0.336	0.392	0.336
Organic Nitrogen(mg/l)	0.896	1.176	0.84	0.448
Total Hardness(mg/l as CaCO <sub>3</sub> )	296	352	254	262
Calcium Hardness(mg/l as CaCO <sub>3</sub> )	138	202	142	148
Magnesium Hardness(mg/l as CaCO <sub>3</sub> )	158	150	112	114
Total Coliform (MPN/100 ml)	43	23	23	23
Fecal Coliform (MPN/100 ml)	9	4	4	3

**Table 4.6 Water Samples Analysis in March 2006**

Parameters	Samples						
	Model Town	Ablowal	Bharat Nagar(A)	Bharat Nagar(B)	Model Town Control	Ablowal Control	Bharat Nagar Control
pH	7.47	7.51	7.56	7.39	7.21	7.37	7.40
Conductivity (m. mho/cm)	0.756	0.619	0.462	0.439	0.620	0.520	0.317
Turbidity(NTU)	0.256	0.235	0.381	0.356	0.184	0.180	0.297
BOD(mg/l)	1.2	1.5	1.5	1.2	1.5	1.2	1.7
COD(mg/l)	32.5	27	22	18	17.5	22.5	20
Alkalinity(mg/l as CaCO <sub>3</sub> )	388	326	260	264	368	306	258
Chloride(mg/l)	0.30	0.34	0.16	0.06	0.34	0.20	0.12
Nitrate(mg/l)	0.116	0.121	0.08	0.134	0.095	0.104	0.100
Nitrite(mg/l)	0.071	0.025	0.076	0.022	0.004	0.003	0.005
Total Phosphorus (mg/l)	0.037	0.052	0.057	0.033	0.040	0.038	0.030
Ammonical Nitrogen(mg/l)	0.340	0.336	0.28	0.28	-	-	-
Organic Nitrogen(mg/l)	0.728	1.232	0.728	0.504	0.840	1.064	0.616
Total Hardness(mg/l as CaCO <sub>3</sub> )	292	372	232	252	282	272	238
Calcium Hardness (mg/l as CaCO <sub>3</sub> )	128	198	144	138	144	148	138
Magnesium Hardness (mg/l as CaCO <sub>3</sub> )	164	174	88	114	138	124	100
Total Coliform(MPN/100 ml)	23	9	4	4	9	3	3
Fecal Coliform(MPN/100 ml)	9	3	3	3	3	3	3

**Table 4.7 Water Samples Analysis in April 2006**

Parameters	Samples						
	Model Town	Ablowal	Bharat Nagar (A)	Bharat Nagar(B)	Model Town Control	Ablowal Control	Bharat Nagar Control
pH	7.09	7.56	7.49	7.30	7.17	7.42	7.34
Conductivity(m. mho/cm)	0.811	0.672	0.475	0.439	0.692	0.548	0.415
Turbidity (NTU)	0.235	0.225	0.390	0.345	0.206	0.181	0.301
BOD(mg/l)	1.5	1.7	1.5	1.0	1.4	1.3	1.8
COD(mg/l)	25	30	17.5	17.5	17.5	15	20
Alkalinity(mg/l asCaCO <sub>3</sub> )	394	334	254	254	408	334	244
Chloride (mg/l)	0.34	0.40	0.34	0.06	0.30	0.24	0.10
Nitrate (mg/l)	0.145	0.165	0.047	0.198	0.130	0.115	0.088
Nitrite (mg/l)	0.086	0.027	0.098	0.012	0.004	0.003	0.005
Total Phosphorus (mg/l)	0.038	0.073	0.053	0.037	0.049	0.035	0.030
Ammonical Nitrogen (mg/l)	0.280	0.336	0.280	0.280	-	-	-
Organic Nitrogen (mg/l)	0.84	1.12	0.616	0.448	0.728	0.952	0.560
Total Hardness (mg/l as CaCO <sub>3</sub> )	280	350	270	270	274	270	260
Calcium Hardness (mg/l as CaCO <sub>3</sub> )	154	244	144	154	144	134	138
Magnesium Hardness (mg/l as CaCO <sub>3</sub> )	126	106	126	116	130	136	122
Total Coliform(MPN/100 ml)	23	9	9	3	3	3	3
Fecal Coliform(MPN/100 ml)	3	3	3	3	3	3	3

**Table 4.8 Water Sample Analysis of a dairy Farm in Rajpura in April 2006**

Parameters	Samples	
	Rajpura Dairy	Control Sample
pH	7.75	7.25
Conductivity (m.mho/cm)	0.873	0.835
Turbidity(NTU)	23.7	9.39
BOD(mg/l)	1.8	1.4
COD(mg/l)	35	22.5
Alkalinity(mg/l asCaCO <sub>3</sub> )	390	370
Chloride (mg/l)	0.40	0.32
Nitrate (mg/l)	0.130	0.080
Nitrite (mg/l)	0.78	0.009
Total Phosphorus (mg/l)	0.065	0.038
Ammonical Nitrogen (mg/l)	0.280	0.224
Organic Nitrogen(mg/l)	1.008	0.56
Total Hardness(mg/l as CaCO <sub>3</sub> )	240	104
Calcium Hardness(mg/l as CaCO <sub>3</sub> )	134	40
Magnesium Hardness(mg/l as CaCO <sub>3</sub> )	106	64
Total Coliform(MPN/100 ml)	43	15
Fecal Coliform(MPN/100 ml)	23	9

**Table 4.9 Results of Soil Sample Analysis**

<b>Parameters</b>	<b>Soil Samples</b>				
	<b>Model Town</b>	<b>Ablowal</b>	<b>Bharat Nagar(A)</b>	<b>Bharat Nagar(B)</b>	<b>Rajpura Dairy</b>
Water Holding Capacity (%)	11.29	11.012	8.38	10.16	12.60
Type of Soil on the basis of Permeability	Clay	Sand	Sand	Sand	Clay
Optimum Moisture Content Test (Degree of Saturation in %)	84.3	68.5	64	67.3	86.5
Nitrate (mg/100 gm)	7.4	9.6	12.4	11.7	15.5
Nitrite (mg/100 gm)	2.2	3.6	3.3	2.9	4.2
Total Nitrogen(mg/100 gm)	5.6	9.8	7.9	6.7	9.0
Total Phosphorus (mg/100 gm)	6.87	7.97	8.20	8.5	9.8
Organic Matter (%)	21.96	20.33	29.72	23.80	24.6
Soil Microorganism (CFUs)	$29 \times 10^{-3}$	$80 \times 10^{-3}$	$80 \times 10^{-8}$	$105 \times 10^{-5}$	$30 \times 10^{-5}$

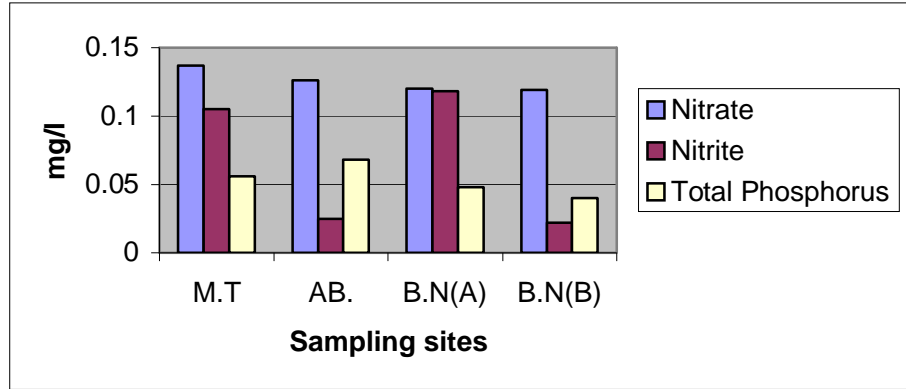


Fig 4.2 Nutrients contamination in Water Samples(Sep. 2005)

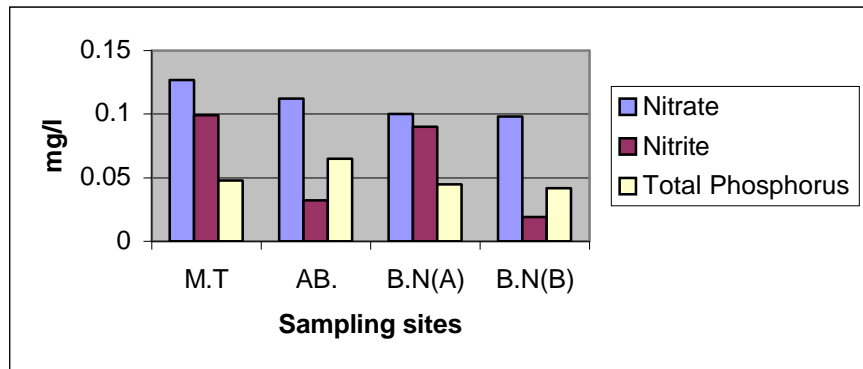


Fig 4.3 Nutrients contamination in Water Samples(Oct. 2005)

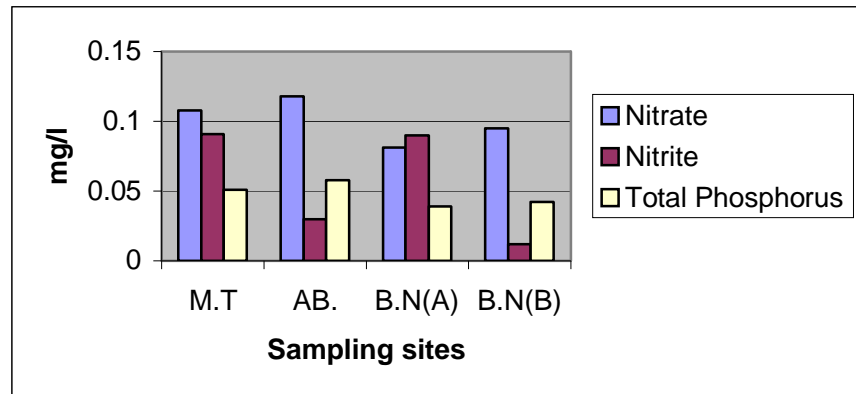


Fig 4.4 Nutrients contamination in Water Samples(Dec. 2005)

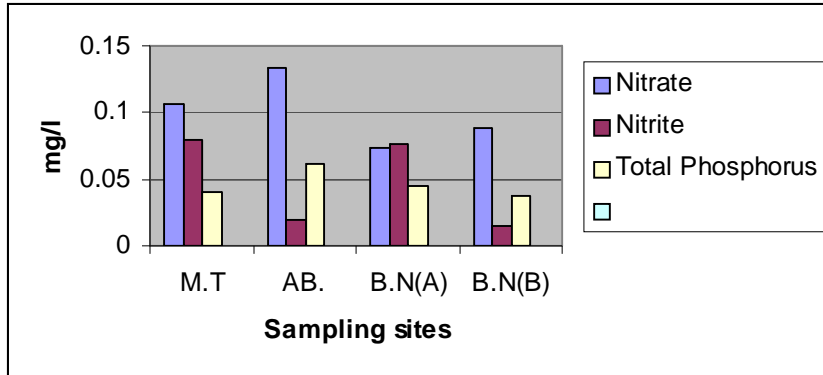


Fig 4.5 Nutrients contamination in Water Samples(Jan. 2006)

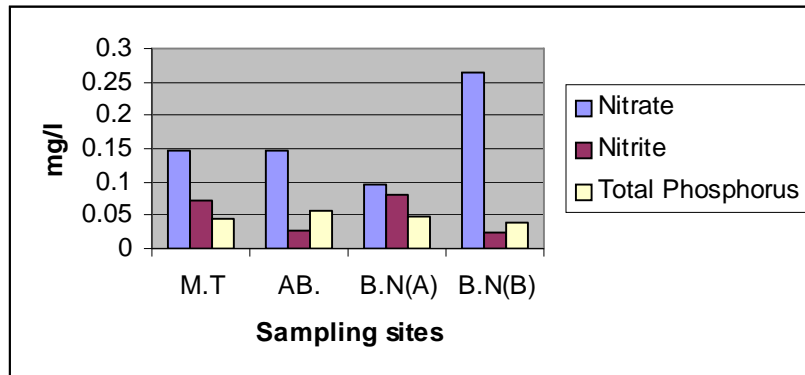


Fig 4.6 Nutrients contamination in Water Samples(Feb. 2006)

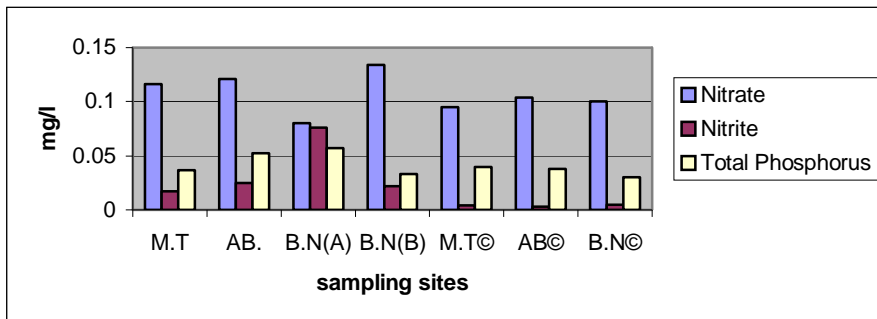


Fig 4.7 Nutrients contamination in Water Samples(Mar. 2006)

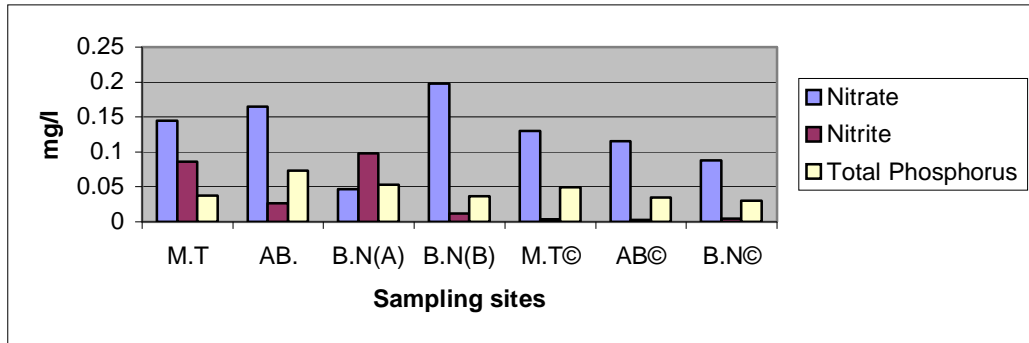


Fig 4.8 Nutrients contamination in Water Samples(Apr. 2006)

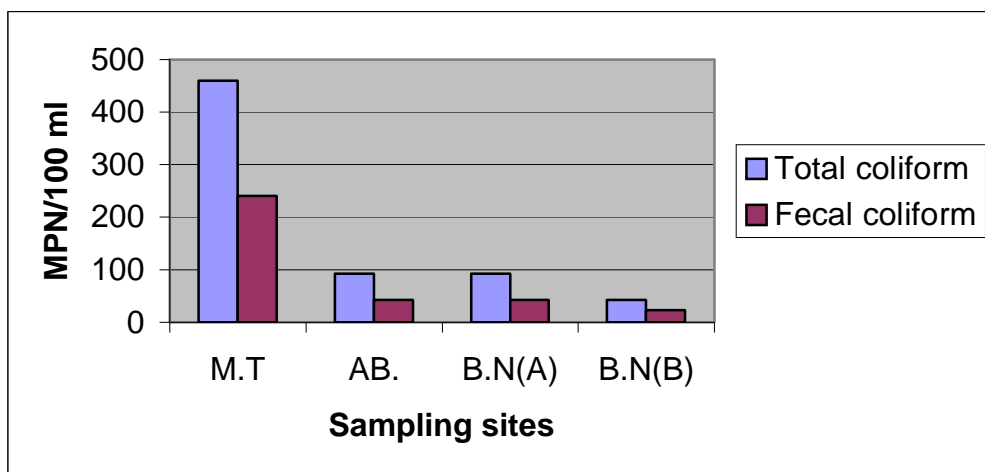


Fig 4.9 Microbial contamination in Water Samples(Sep.2005)

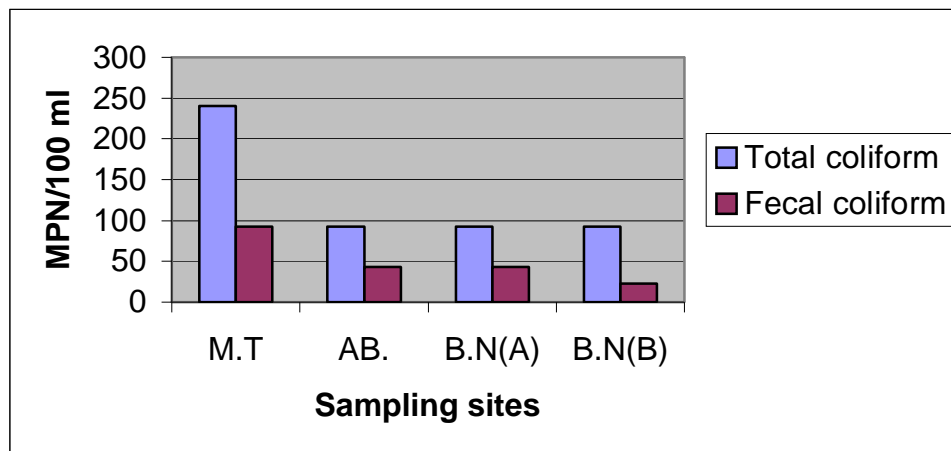


Fig 4.10 Microbial contamination in Water Samples(Oct.2005)

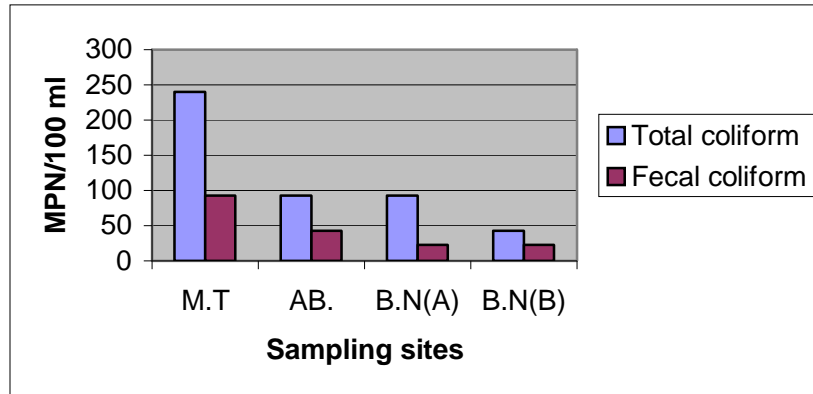


Fig 4.11 Microbial contamination in Water Samples(Dec.2005)

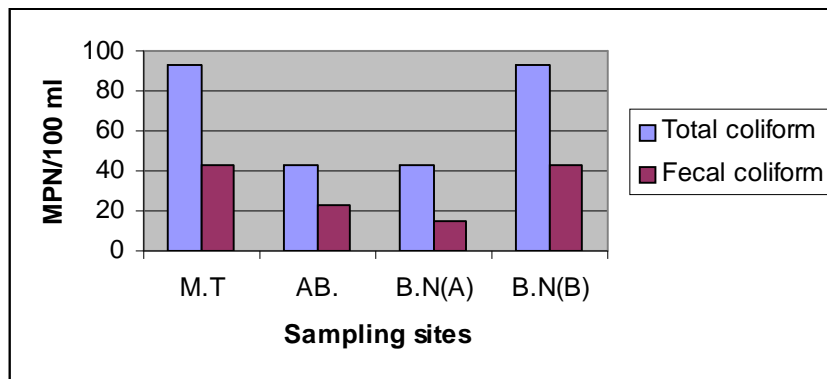


Fig 4.12 Microbial contamination in Water Samples(Jan.2006)

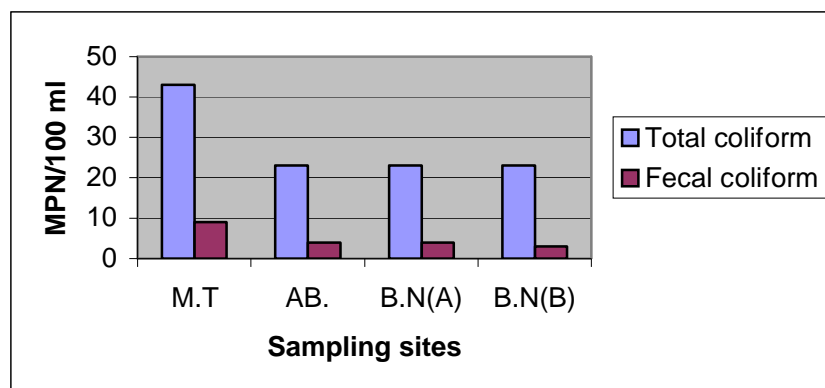


Fig 4.13 Microbial contamination in Water Samples(Feb.2006)

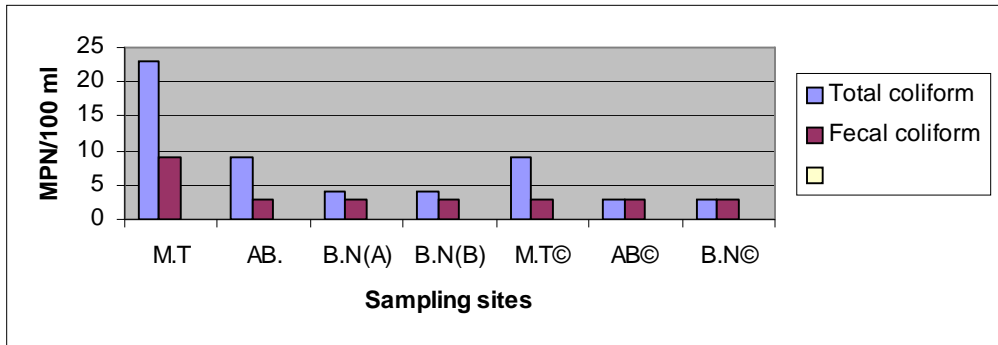


Fig 4.14 Microbial contamination in Water Samples(Mar.2006)

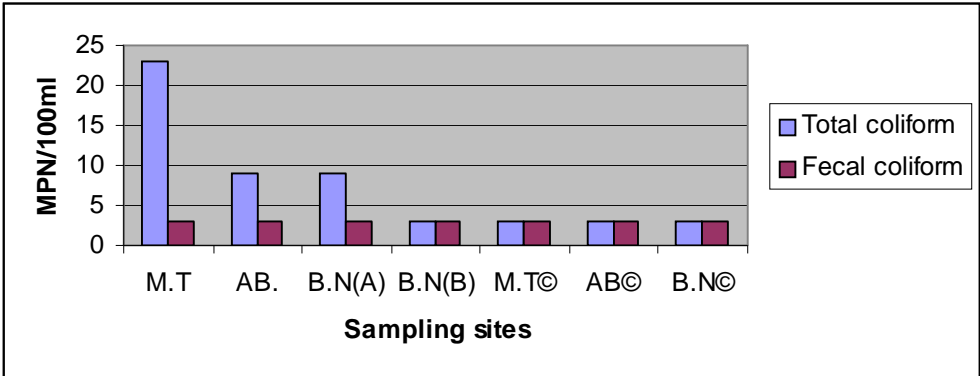


Fig 4.15 Microbial contamination in Water Samples(Apr.2006)

## **CHAPTER: 5 CONCLUSIONS**

Based on study performed on, assessment of Ground water quality at Animal farms the following conclusions are drawn

- Groundwater pollution occurs around all the animal farms. Forms of nutrient and presence of Coliform are more objectionable than other parameters.
- Hence safe and sanitary disposal of animal wastes is a necessity for protecting Groundwater.
- The soil quality favours the seepages of wastes thus altering Groundwater quality easily.

### **Future Scope**

1. A mathematical modeling to establish the relationship between animal farms and Groundwater quality.
2. Study on Health effects on people living around animal farms.

## SUMMARY

Water occurs as Surface and Ground water .Ground water in comparison is purer than Surface water. Yet, multiple sources such as domestic sewage, industrial waste water, animal farms contaminated the Ground water.

Several animals farms exists within city of Patiala, where Ground water is a major source for drinking and irrigation.

Ground water quality was assessed in collected samples monthly of monsoon, winter and pre-summer seasons at four stations i.e. Model town, Ablowal village, Bharat Nagar(A), Bharat Nagar(B), beside at dairy farm in Rajpura. To confirm the results , control stations were also fixed and samples of Grab were collected.

Extent of Ground water pollution varied from station to station as well as with respect to season of the year. Raining season deteriorated the water quality than other seasons.

Soil analysis collected at /near animal farms provided physical-chemical characteristics which could be correlated with water quality.

Further it was suggested for necessity of Mathematically modeling the source of pollution in relation to Ground water

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