STATUS OF SULFUR IN SOIL TREATED WITH INDUSTRIAL WASTE OF WAZIRPUR, DELHI

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CERTIFICATE

The research work embodied in this dissertation entitled **"STATUS OF SULFUR IN SOILS TREATED WITH INDUSTRIAL WASTES OF WAZIRPUR, DELHI"** is done by Gurmeet Singh under the supervision of Prof. A.K Bhattacharyya in partial fulfillment of the requirements for the degree of Master of Philosophy. The work has been carried out in the School of Environmental Sciences, Jawaharlal Nehru University, New Delhi. The work is original and has not been submitted in part or full for any other degree or diploma to any university.

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To my dear parents.........

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Chapter I

Introduction

Over the past several decades, the rapid globalization of the world economy has led to phenomenon levels of economic growth, particularly in the northern hemisphere. However, this economic growth has brought with its side effect, including the generation of an increasing volume of hazardous waste. India is one of the few developing countries, trying to raise its position in global market.

Not so long ago, man was convinced that science and technology would create a paradise on earth, which it succeeded to certain extent. But, unfortunately there has been another side of the coin. Industry is often considered as environment's major enemy. Industry is not only criticized for processes that pollute, but also for creating products that are wasteful of scarce resources. The age of industrialization has brought severe damage to the environment by degrading land, water and air. This environmental degradation is directly related to population growth, industrialization, rise of living standard, urbanization etc.

Nearly every anthropogenic activity leaves some kind of wastes. Households create ordinary garbage; industrial and manufacturing processes create solid and hazardous waste.

Waste can be defined as any movable material, that is perceived to be of no further use and that is permanently discarded. Under London Convention1972, Waste were defined broadly to include the 'material and substances of any kind, form and description.' Basel Convention, 1989, on the other hand defines waste by reference to there end use; they are the substance or objects, which are disposed of, or are intended to be disposed off or are required to be disposed of by the provision of national law." Once in the environment, wastes frequently cause damage to ecosystems and human health and therefore act as pollutants.

Waste can be defined according to their source of origin. They can be mining, agriculture, industrial, municipal wastes and sewage sludge, among them industrial process wastes encompass a very wide range of materials and may include general factory rubbish, packaging materials, organic wastes, acids, alkalis and metalliferous sludge It creates problems because it is unwanted. Per capita waste generation varies between 2.75-4.0 kg per day in high-income countries, but is as low as 0.5 kg per day in these countries with lowest income (Santra, 2001).

Industrial waste is more troublesome than other wastes. It consists of toxic inorganic, organic and high concentration of heavy metals, which are causing harmful health effect to the living organisms and ecosystem (Subrahmanyam, 1991). Solid wastes may be hazardous or non-hazardous. 'Hazardous wastes' could be defined as "The wastes other than radio active wastes which by reasons of their chemical reactivity or toxicity, explosive, corrosive or other characteristics causing danger or like to cause danger to health or the environment, whether alone or coming into contact with other wastes, are legally defined as hazardous in the state in which they are generated or in which they are disposed of or through which they are transported"[UNEP, 1989]. Not cited ?

Not cited ?

As the industrialized society generates more hazardous waste, there is an increased need to find a way to dispose it of in an environmental friendly manner. Prior to 1970 the industrialized north disposed off these waste within their own countries, often with little regard to the environmental impact of disposal. However as incident of improperly disposed off waste, such as The Love Canal affair, in the United States began to create serious health and ecological problems, public awareness of the consequences of improper disposal increased. Eventually this awareness led people in industrialized countries to expressing an increasing unwillingness to have waste disposed of at home [The NIMBY (not in my backyard) syndrome].

Global production of hazardous wastes is estimated to be at least 3.38×10^{11} kg per annum (1991 data), about 80% of which is generated in the USA. In some countries the rate of increase appears to be phenomenal. For example, estimates of South Korean hazardous waste production for 1985 and 1989 are 1.2×10^{10} and 2.1×10^{10} kg per annum, respectively. It is interesting to note that 41% of the solid industrial waste generated in the USA is categorized as hazardous. This compares with 33.5% in Hungary, 3% in the UK and 0.3% in Japan and Italy (1992 data).

1.1 Legal Status

International regulation regarding the solid waste management began in the early seventies with the adaptation of two treaties, which prohibited the disposal at the sea of certain type of waste (The Convention on the Prevention of Marine pollution by Dumping of waste and other matter, London 1972; And International convention for the prevention of pollution from ships [MARPOL] 1978.)

Table.1.1: Share of continents (developing countries) receiving hazardous waste from developed countries

Hazardous waste shipment status (1987-1988)	
Continent	Amount (tons)
Africa	507668.7
North America	54386
South America	29,758
Asia	6209
Europe	3052818

(Santara, 2001)

At global level, no UN or other body has overall responsibility overall responsibility for waste which has led a fragmented, ad hoc and piece-meal international response. The Stockholm Conference did not really grapple with the issue of waste, as in 1972 the problem was not as severe as it is now. Without specifically mentioning waste, Principle 6 of the 1972, declaration called for the discharge of toxic and other substances to be halted. The 1982, world Charter for Nature called for the 'special precaution' to be taken to prevent the discharge of radioactive or toxic waste, but it kept mum regarding the minimization of generation of such type of waste .At UNCED, the issue of waste was addressed in some details in Agenda 21 with development of proposal, including target and timetables, for the management of hazardous and other waste, and radioactive waste. Agenda21 distinguishes between Hazardous waste, solid waste (including Sewage), and radioactive waste. Principle 14 of Rio declaration limited itself to calling for the effective co-operation to discourage, or prevent the relocation of transfer of to other states of any activity and substances that caused severe environmental degradation or are found to be harmful to human health. The goal of Basel convention was ESM [Environment Sound Management], which addresses " Integrated Life Cycle approach " which involves strong controls from the generation of a hazardous waste to its storage, transport, reuse, recycling, recovery and final disposal. In other words the minimization of hazardous waste whenever possible. Despite of these convention and global consensus, many of the developed countries turned a deaf ear towards the problem of solid waste disposal

ISWA (International Solid waste Association) was founded in Essen, Germany in 1970 by founding members from Germany, Austria, Switzerland, France, Italy and UK. It is a non-profitable, non-government organization, having headquarters in Copan Hagen, Denmark. It has a membership strength of 75 countries and it acts a component partner of UNEP. (http://www.test.iswa.org/pdf/AnnualREPORT2002.pdf) It has the objectives to disseminate information on the all aspects of solid waste management as well as to exchange information

1.2 Disposal of Hazardous Wastes

In addition to the hazardous wastes currently being produced, considerable amounts have been inappropriately disposed off in the past. Historically, the bulk of hazardous waste has been disposed off to landfill, often with little or no pretreatment. It is clear that ill-considered landfill practices have caused and continue to cause environmental damage at a large number of sites. Consequently, a large number of sites have been contaminated and are potentially hazardous. For example, 32000 such sites have been identified in the USA alone (1991 data). The remedial treatment of these is likely to be extremely costly.

There is also a legacy of materials that are now known to be hazardous, but that were once in common usage. Disposal of these substances is likely to cause problems for some time to come.

Today, disposal of solid wastes in developed areas is largely by dumping in landfills and by incineration. Composting of garbage is being practiced in many parts of the world, dumping them in the sea is practiced in some parts of the world. Wastes generated from different sources cannot be disposed of safely without being treated.

1.3 Hazardous Waste Treatment

The three R's Reduce, Recycle and Recover in an industry are the important pillar of the solid waste management. Strategies for the treatment of highly hazardous wastes can be divided into those aimed at reuse, at destruction or immobilization.

Table 1.2: Categories of hazardous waste

Waste Category	Type of wastes	Regulatory Quantity (kg/Year)
No.1	Cyanide Wastes	1(as cyanide)
No.2	Metal finishing Wastes	10(the sum of the specified substance calculated as pure metal).
No.3	Waste containing water soluble chemical compounds of Pb, Cu, Zn, Cr, Ni, Se, Ba Sb	10(specified substance as pure metal)
No.4	Mercury, Arsenic, Thallium, and Cadmium bearing wastes	5(specified substance as pure metal)
No.5	Non-halogenated hydrocarbons including solvents.	200(as non-halogenated hydrocarbon.
No.6	Halogenated hydrocarbon including solvents.	50(as halogenated hydrocarbons)
No.7	Wastes from paints, pigments glues, varnish, printing ink.	250(as oil or oil emulsions)
No.8	Wastes form dyes and dye intermediates containing inorganic chemical compounds	50(as inorganic chemicals)
No.9	Wastes from dyes and dye intermediates containing inorganic chemical compounds.	200(as inorganic chemical)
No.10	Waste oil and emulsion	1000(as oil, oil emulsion)
No.11	Tarry wastes from refining and tar residues from distillation or pyrolytic treatment.	200(as tar)
No.12	Sludge arising from treatment of waste waters containing heavy metals, toxic, organics, oil emulsions and spent chemicals and incineration ash.	Irrespective of any quantity.
No.13	Phenols	5(as phenols)
No.14	Asbestos	200 (as asbestos)
No.15	Wastes from manufacturing of pesticides and residues from pesticides and herbicides formulation units.	200 (as pesticide and their intermediate products)
No.16	Acidic/alkaline/slurry waste	200 (as acid/alkali)
No.17	Off-speciation and discarded products	Irrespective of any quantity.
No.18	Discarded containers and container liners of hazardous and toxic wastes.	Irrespective of any quantity.

(Source: Freeman H.W. (1988). Standard Handbook of Hazardous Waste Treatment and Disposal)

Not in Ref

The most effective strategy for reduction of solid waste generation is the reduction at source.

Options for reuse include purification followed by recycling. This approach is frequently applied to solvents, as recovery of pure material from waste solvent is often achievable by distillation. An alternative approach is to use the waste from one process as a feedstock for another. There are instances, where the waste from one process can be used to treat the waste from another. Reuse within the facility that generates the waste is desirable as the need for transport is minimized. Alternatively, the wastes generated by one manufacturing company may be used directly by another. In some cases establishment of "waste exchanges" has encouraged this practice.

Destruction of highly hazardous wastes is only applicable to those that are hazardous by virtue of molecules that they contain rather than their constituent elements. For example, wastes containing CN^- may be detoxified by treatment with chloride (Cl_2), thus:

$$CN^-(aq) + H_2O(l) + Cl_2(aq) = OCN^-(aq) + 2HCl(aq)$$

Followed by

$$OCN^-(aq) + H_3O^+(aq) = NH_3(aq) + CO_2(aq) .$$

An important component of the hazardous solid waste is the toxic heavy metals generated by metal processing industries, rolling & pickling industries and mining industries. These metal can't be destroyed. Cu, Ni, Cd, Pb, Hg, Zn and many other heavy metals can be largely removed from the water by the addition of an anion that causes the precipitation of the metal as an insoluble salt. Anions used for the purpose include sulfate (SO_4^{2-}), sulfide (S^{2-}) and hydroxide (OH^-).

The solid waste can be disposed of by means of various thermo-chemical processes such as incineration, pyrolysis and wet air oxidation. Incineration finds greater advantage in the disposal of materials, such as hospital wastes, that may be contaminated with pathogens. Other thermo-chemical treatments applicable to hazardous wastes include pyrolysis and wet air oxidation.

Biological methods of hazardous waste disposal have been used for sometime. In case of land farming, oily wastes are spread onto the soil. Decomposition may be enhanced by the addition of organic fertilizers and the periodic disturbance of the land using conventional agricultural implements How it is

ever interesting to note that disposal of sewage sludge on farms is to be banned in Switzerland by 2005. The move is in response both to a reduction in demand for sludge and increasing concern about the residues in the sludge, particularly synthetic hormones and some pharmaceutical compounds. (Waste Management World, November- December 2001; http://www.jxj.com/wmw/)

Wastes that are neither recycled nor destroyed must be disposed off.This can be done with much greater safety if the waste is immobilized first. The technologies used to do this involve either the incorporation of waste into a solid matrix or its encapsulation within an impermeable polymeric cover. In addition to immobilization these processes are variously referred to as stabilization, solidification or fixation.

Other procedures that are used for the disposal of hazardous wastes include dumping at sea. For example, in 1985 the UK disposed of about 2.3 x 10^8 kga^{-1} of chemical wastes in this way. However there have been political moves to curb this practice. It was agreed by the 13th Consultative Meeting of the London Dumping Convention (1972), that all sea dumping of non-inert industrial waste should cease by 31 December 1995.

What is this unit ?

Hazardous wastes have also been disposed of by placement at depth within the earth, well out of reach of potable aquifers. This has been done within unused mines and by deep-well injection.

A note of caution is required regarding the development of new methods of disposing of the wastes. Great care must be taken to consider every possible environmental implication in the development of any new system. What may appear to be the ideal solution today may in fact prove to be, tomorrow's environmental headache. Careful research and thorough investigation into the impact of all methods of waste disposal on the environment are necessary, along with well executed management and control of the systems which are ultimately utilized

1.4 Waste Management in Delhi

The national capital of Delhi, with a population approximately of 14 million, covering an area of 1483 sq km has emerged as one of the biggest centres of small-scale industries in the country. It is highly polluted due to a large number of existing industries. It has a cluster of small-scale industries with a spectacular growth during the period of 1968-1996, which is shown in the table no.1.2. (Office of the Commissioner of Industries, Delhi, 1996. These estimates are approximation based on surveys conducted by Industries Dep't. & DPCC.)

Table 1.3: Growth of industries in Delhi

Year	No. of units
1951	8,160
1961	17,000
1965	19,038
1968	23,496
1978	40,000
1985	65,000
1988	76559
1990	81,000
1992	89,000
1996	1,26,218

(http://www.smallindustryindia.com/policies/state/delhi/pstdl02x.htm)

(Data of year 1998)

According to the study conducted by National Council of Applied Economic Research (NCEAR), there are 28 approved industrial areas in Delhi with a total of 21,627 registered industrial units. As per survey conducted by the NPC in 1998, There are total 1,26,218 industrial units in 28 authorized industrial estates and several non-conforming areas. Apart from these, new location has been coming up as developed industrial area. Nearly two third of the all industrial units are located in six larger industrial area namely Anand Parbat industrial satate (17.23%), Mayapuri Industrial area (15.10%) Okhala industrial area (9.59%), Wazirpur industrial area (7.70%) and Kirtinagar industrial Estate (6.82%). only one third of the units are located in the remaining 22 industrial areas

estate

Table1.4 List of approved industrial areas in Delhi

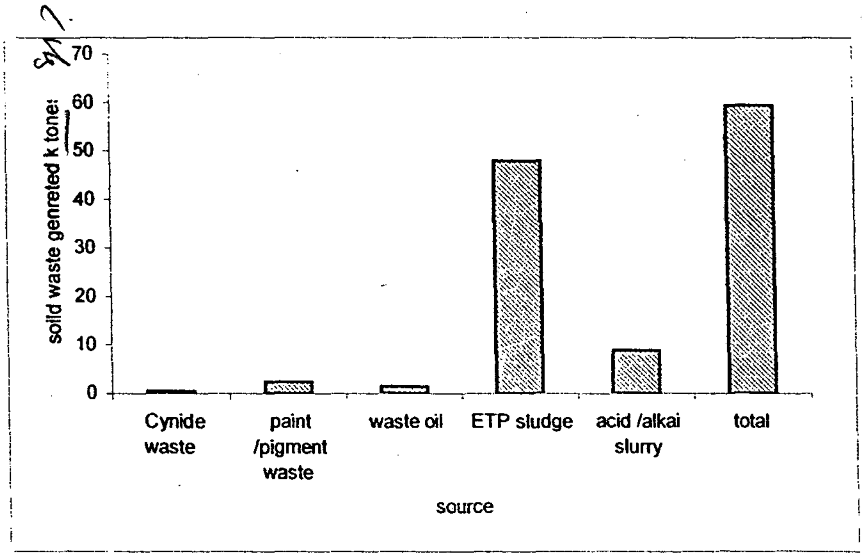
S. No.	Industrial area/ estates
1	Wazirpur industrial area
2	G.T.Karnal Road Industrial Area
3	Lawrence Road Industrial Area
4	Udyog Nagar
5	Rajasthani Udyog Nagar Industrial Estate
6	S.M.A. Industrial Area
7	S.S.I. Industrial Area.
8	D.S.I.D.C.Nangloi Industrial Area
9	Mangolpuri Industrial Area
10	Okhla Industrial Area
11	Okhla Industrial Estate
12	Okhla Flatted Factory Complex For Electronics
13	Naraina Industrial Area
14	Mayapuri Industrial Area
15	Badii Industrial Area
16	Jhilmil Industrial Area
17	Friends Colony Industrial Area
18	Patpargang Industrial Area
19	Mohan Co-operative Industrial Area
20	Tilak Nagar Industrial Area
21	Kirti Nagar Industrial Area
22	Najafgarh Road Industrial Area
23	Moti Nagar D.L.F. Industrial Area
24	Birla Mill Site on G.T.Karnal Road Area
25	Flatted Factories Complex Jhandenwalan Industrial Area
26	Anand Parbat Industrial Area
27	Shahadra Industrial Area
28	Narela D.S.I.D.C. Industrial Area

Recent reports have shown that approximately 6,700 metric tones of solid waste is generated per day in Delhi (Indian Express May 2004). Many agencies have performed the hazardous waste inventory for the state of Delhi and their estimates are given below. (Terivision, September 2001, Vol 38)

- 59,423 tones per year (data obtained from the MoEF [Ministry of Environment and Forests] 2000, Figure 1)
- 60,000 tones per year (NPC 1997)
- 24,000 tones of CETP (common effluent treatment plant) waste per year as

tones should be written either as tons or tonnes per NEERI (National Environmental Engineering Research Institute) (NPC 1997, Figure 2)

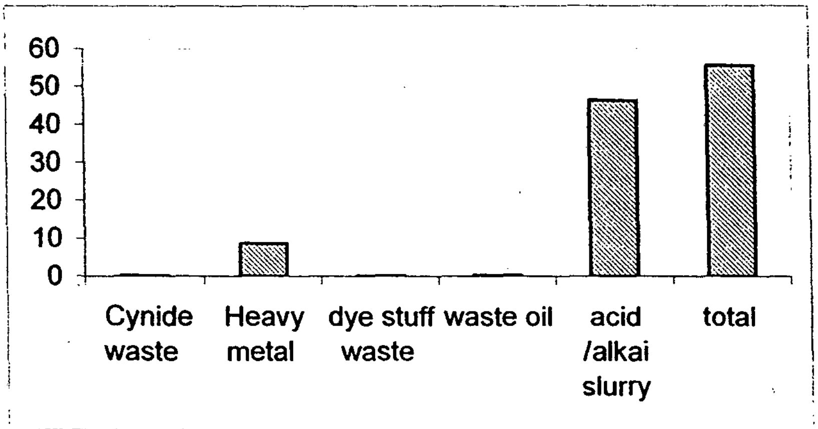
Figure1. 1 Hazardous waste generation in Delhi



Source: MoEF, Government of India (2000)

Figure1. 2 Hazardous waste generations in Delhi

Unit ?
y-axis ?



Source: NCAER, 2002 UNPUBLISHED DATA &: NPC 1997 DATA

n

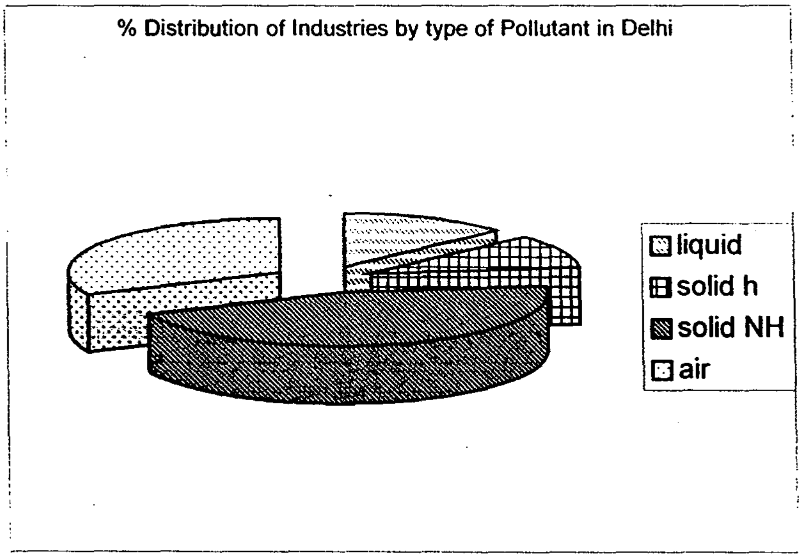
The survey conducted by NPC (National productivity Council) has showed that of the total industrial units 18.59 % are engaged in metal processing industries (15.29% Manufacture of fabricated metal products, 3.30% manufacture of Basic iron and steel processing). Out of these nearly 80% are operational without licenses (88% in the former case and 81% in the later case). More than 50% of the industrial units are the major source of solid waste pollution in Delhi

Table1.5 survey of Industries of Delhi regarding the waste generation and pollution control

Total number of responding units	13,785
Total number of polluting units	3,680
Total hazardous waste generating units	2613
Total quantity of hazardous waste generated from these units	151588 kg/day
Total quantity of sludge from proposed CETPs.	57 M^3/day

(**Sources:** NCEAR Report 06 Oct. 2003)

Figure 1.3 Distribution of Industries by type of Pollutant in Delhi



(**Source:** NCEAR Report 06Oct 2003)

A large number of industries including hazardous ones are located in non-confirming areas especially in the vicinity of residential areas. "Wazirpur Industrial Area" is a major industrial area releasing a significant quantity of hazardous solid wastes. It was set up in early 1960s to accommodate the hosiery industry. But today 75% of the industrial units are process steel industries. It is surrounded by residential areas such as Shalimar Bagh, Ashok Vihar, Azadpur Sabzi Mandi , Model Town, etc.

The total number of industrial units of Wazirpur Industrial Area is 1665, among these 1379 have responded to the study done by NCAER and 189 units are not responding at all either to any correspondence from any agency or to the survey team. Another 97 industrial units have been reported to be either closed or shifted(NPC, 2002 unpublished). Of all small-scale industries located in this area, only around 50% are registered and operating legally. To make the situation worse the workers and their families also inhabit the place although being strictly an industrial area. They dwell in slums under extremely unhygienic condition. Out of these 1665 industries only 424 are registered (Giri, And Bhattacharyya 1999) . Industrial area of Wazirpur is divided into different industrial blocks namely A, B, C. during the last decade there has been 3-fold increase of industries in this area. The then statistics showed that there were about 1000 industries out of which only 424 were registered. A list of registered industries in different blocks has been shown in tables 1.6 and 1.7.

Table 1.6: List of registered industries in Wazirpur.

Blocks	no. of industries
A	262
A-group	80
B	36
C	46
TOTAL	424

Source: Small-scale Industrial Association, Wazirpur, 1995

Table 1.7: List of various industries in Wazirpur.

Textile	46
Electroplating	20
Rolling and pickling	50
Soap	10
Others (rubber, plastic, Candle & Engineering etc.)	30
TOTAL	156

Source: Small-scale Industrial Association, Wazirpur, 1995.

The main polluting industries in this area are rolling, pickling, electroplating and textiles, etc. the large number of these industries are spewing huge amount of toxic wastes everyday. The establishment of residential units in non-conforming areas, commercial complexes and other human activities within the industrial premises has already magnified the problem to greater extent.

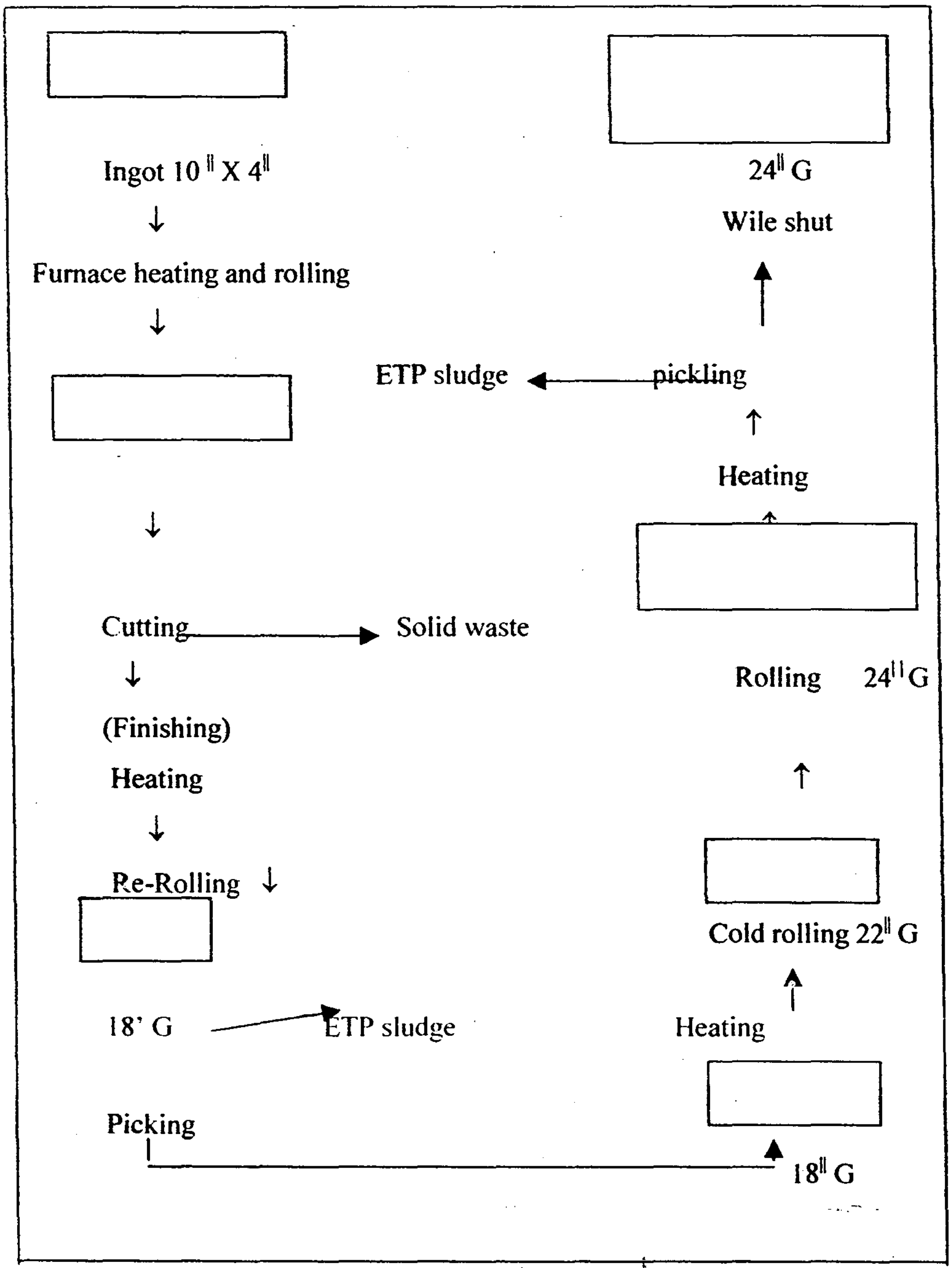
The NIMBY syndrome is quite prevalent here. These industries in order to skip from environmental legislation often dump their waste (which is extremely acidic in nature and have very high concentration of heavy metals) on roadsides, in sewers, along with Municipal waste or even in the industrial premises. The wastewater sweeps away in open drainage and underground sewage system, which gets accumulated over the streets and become a streamlet with the dirty and hazardous waste materials of industries. The heavy metals and other ions ~~are~~ leached into ground water, affects the ground water quality, biota and even the health of the people living in nearby surrounding area. Whatever wastes are generated from these units are highly acidic (pH 2.3-3.8) in nature, since huge quantity of acids being used while picking of the metal sheet. High concentration of heavy metals like Fe, Zn, Cu, Mn, Cd, Pb are present in this waste making it highly hazardous (Giri and Bhattacharyyai 1999.)

Hazardous waste management in Delhi can be better placed by minimization at the point source as well as shifting/ relocating industrial units producing hazardous wastes from non-conforming areas to conforming ones. For treatment and disposal of hazardous wastes in Delhi, keeping in view the scattered nature and small size of the units, a central hazardous waste treatment and disposal facility adopting CETPs is an option to dispose hazardous waste in a cost-effective and environment-friendly manner by recovering and recycling certain costly chemical constituents.

1.4 Waste Disposal in Soil

A variety of wastes find their way in the soil. They are dumped in various dumping sites separately along with municipal solid waste untreated or after chemical treatment or often they are disposed off untreated. Soil is a mixture of inorganic and organic solids, air, water and microorganisms. All these phases interact and influence each other. Physiologically, Delhi consists of the Yamuna flood plain, the old Khaddar (earlier flood plain), and the Bangor (upper alluvial plain). Thus, a major part of Delhi is covered by the Yamuna alluvial soils. Fourteen soil series observed in the state of Delhi (NEERI).

Fig. 1.4: Flow diagram of the process of Pickling and Rolling industry and generation of waste in different steps



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The present work is one simple step in an attempt to dispose safely the solid waste, generated from the industries like pickling and rolling, on the land. It can be used as organic manure also after proper physiochemical treatment. Our lab under the supervision of Prof A.K.Bhattacharyya has been engaged during past 14 years in working out the possibilities for disposing these wastes to soil.

These industrial wastes are highly acidic pH ranging from 2.12 to 4.5, and also contain the essential elements (N, P, K,). Mixed along with toxic elements. My senior colleagues have undertaken various physiochemical and microbial studies of the wastes treated with lime and then mixing it with the soil. I have been entrusted with the study of status of sulfur in soil mixed with this industrial waste and treated with lime

Sulfur is usually ranked as thirteenth most abundant element. Plants in relatively higher amount for good crop growth need sulfur, an essential macronutrient. It is needed in the same quantity as phosphorus. Like Nitrogen it is also subjected to biological and chemical oxidation-reduction reactions. The ~~sulfur~~ in most arable land is in the form of organic matter; sulfate either in soluble form or in adsorbed form. Appreciable amounts of exchangeable SO_4^{2-} may be present. In subsoil that contins1: 1 clays and hydrous oxides of iron and aluminum, Sulfur is present in different form and in oxidation states ranging from +6(SO_4^{2-}) to –2 (in H_2S). Plants usually take up the sulfur as the SO_4^{2-} ion. Concentration of 3-5 ppm has proved to be adequate for the growth of many plants species. Rapeseed and alfalfa appears to require higher concentration

Adsorbed sulfate is an important fraction of some soil, particularly those containing large amounts of hydrous oxide of aluminum and iron. In certain soil, adsorbed sulfate may not be as rapidly available as soluble SO_4^{2-} and it may be released over a longer periods of time. Elemental sulfur, sulfides and several other inorganic sulfur compounds can be oxidized in the soil by microbes. One important class for the oxidation is chemolithotropic bacteria (Thiobacilli). The activity is shown as

$$CO_2 + S + \tfrac{1}{2} O_2 + 2 H_2O \longrightarrow [CH_2O] + SO_4^{2-} + 2H^+$$

Sulfur has been successfully introduced to various fertilizers such as ammonia, CSP, ammonium phosphate urea solid and fluid N-P-K materials. Its

Table 1.8: Sulfur requirements by various crops

Crops	Sulfur required as fertilizer in deficient areas (kg S / ha)
Group 1 (high) m	
Cruciferous forages	40-80
Lucerne	30-70
Rapeseed	20-60
Group II	
Coconuts	-50
Clovers and grasses	10-40
Coffee	20-40
Cotton	10-30
Sugarcane	20-40
Group III	
Sugar beet	15-20
Cereal forages	10-20
Cereal grains	5-20
Peanuts	5-10

what is the source of the table ?

usefulness as a plant nutrient, depends upon, the rate at which it is oxidized to sulfate

Since for cleaning of metal and metal related products, sulfuric acid is used in huge amount in rolling and pickling industries at Wazirpur Industrial area, the waste generated has very high concentration of Sulfate 200-300 ppm. The aim of present study is to find out that whether the waste after proper treatment, can be safely disposed on land.

OBJECTIVES

The objectives of present studies are-----

- To analyze the physico-chemical parameters (including Sulfur) of the industrial wastes collected from Wazirpur Industrial Area
- To analyze changes in physico-chemical properties (including Sulfur) of the two types of soils (Chhattarpur and JNU, Delhi)
- To study the status of Sulfur in these two soils mixed with different proportions of the above-mentioned industrial wastes, treated with and without two doses of lime

Chapter II

Review of Literature

The problem of industrialized world is the disposal of toxic and Hazardous wastes, coming out of different industries. They are required to be treated before their disposal. The problem of disposal of waste has compelled the industries to utilize the wastes, recycle them or treat them so that they can be easily disposed off. There is a pressing need to develop clean technologies that recycle waste materials in eco-friendly manner. Traditional evaluation of waste management and treatment is often based on emission standards, recycling rates, product quality, costs and public acceptance.

Soil is the complex mixture of the decomposed organic material and eroded rock textures on of earth's surface that support plants, they underlie the foundation ? of houses and factories and determine whether the foundations are adequate. Having miscellaneous properties with the integrated effects of climate and living matter acting upon parent material, as conditioned by relief, over period of time (USDA, 1951). People are dependent on soil, and conversely, good soils are dependent on people and the use they make of the land soil also have other ?? meaning of human kind. Soil absorbs wastes from sewage systems, wastes from other municipal, industrial, and animal sources.

Sewage sludge is the solid byproduct of domestic and / industrial waste, water/ treatment plant. Philadelphia has developed a system of composting and of land application of sewage sludge on a basis for its sources (Lochar, 1979). Heavy annual application of sludge on land can increase the organic matter and nitrogen content of the soil (Sheaffer, 1979). UK has been interested towards the mechanical use of dewatering and applying liquid sludge directly to the land (Standridge, 1971). Industrial wastes are major contributor to the U.S. solid-waste management problem. For the sound disposal of industrial solid waste it is necessary to know rate of generation of waste and properties of wastes (Niessen, 1977).

Not cited in Refer

Solid waste treatment options (recycling, incineration, and land filling; the two latter processes both co-generations of heat and electricity) have been studied by Dewulf and coworkers for cardboard, newspaper, polyethylene, terephthalate, polypropylene, polystyrene and polyvinyl chloride waste. Taking into account of the waste materials and the resources to convert them, it has been proved that recycling is the most efficient option for polyethylene with efficiency of 62.55 versus 43.6% for incineration and 10.9% for land filling.

Heavy-metal polluted soils have for long been recognized as a serious problem in industrialized part of Western Europe (Alloway 1993) and North America (Hutchinson and Whitby 1997), and it has recently become apparent that the problems in Eastern Europe and Russia are in many cases even more extensive (Kozlov et al. 1993). In heavily polluted areas of this sort there are usually two main forest damage zones (Tikkanen and Niemelä 1995): an industrial barren zone relatively close to the point emission source where the tree and ground vegetation are completely destroyed, and an outer zone where the vegetation is progressively suffering from serious damage but is capable of slow recovery if its emissions are drastically reduced.

Where is the Reference ?

~~Land disposal of liquid sludge effects on soil pH.~~ The Ca-sludge increased soil pH, availability of P from Ca, Fe, and Al sludge in soil (King and Morris, 1972; Soon, et al 1978). Lime amendment is a common method for neutralizing the accumulated acidity and sequestering metals in oxidized mine tailings. A study by Catalan et al (2002) assessed the reactivity of sulfide oxidation products during lime treatment of tailings samples from the Kim Katie mine site in Timmons, Ontario. Insoluble Fe-oxy- hydroxyl-sulfate minerals were responsible for the majority of alkalinity consumed by oxidized tailings during lime treatment. Cattle manure can increase soil pH and supply considerable quantities of available nutrients (P.K) in Japan (Whalen, et al., 2000).

Where is refere ?

Due to rapid industrial development during the last ~~two~~ decades in India (growth rate 6.4 per annum), the disposal of industrial effluents has become a serious problem. The tannery and textile are two important industries in the country. The application of these industrial effluents to land has also been started during recent years as an alternative means of treatment and disposal. This supplies not only water (a source of irrigation) but also manorial ingredients and plant nutrients like N, P, K, S and Ca etc. If these effluents are treated properly and reused judiciously in agriculture, they may serve as a source of irrigation and source of plant nutrients. Soil acidity limits nutrient availability to plants , leads to crop production and yields. Soil acidity raises the cost of production due to regular apply of lime. Recent experiments have shown that increase in sol acidity can decrease the soil CEC and addition of lime causes reverse effects (Bauer David K 1999).Overliming usually decreased the concentration of basic cations (i.e. Mg, K, and Na) other than the Ca. But as incubation progressed the solution concentration of Ca, Mg, K, and Na increased in both lime and unlimed soils (Curling 1995). From the study done by Maiti et al. (1990) it is evident that application of fly ash to acid soils is likely to neutralize acidity. However, in neutral to alkaline soil, the addition of fly ash may reduce the availability of micronutrients due to rise in pH. It can be mixed in light textured soils to increase their water holding capacity. Over and above fly ash appears to be good source of available P and K.

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Soil samples were collected from land irrigated by trade effluent from electroplating units, by water of Hakimwala drain situated in Amritsar and of by Budha Nallah located in Ludhiana, both carrying industrial effluents and domestic sewage (Kansal et al, 1993). The results reveal the presence of significant amounts of chromium, nickel and zinc in the adjoining soils and water. In view of the common practice of application of effluent on land for agricultural purposes in the areas close to the drains, consequent harmful effects have to be anticipated of and remedial measures need to be taken.

Field survey for assessing ground water quality and salinity build-up in irrigated soils of Sikandarabad area of Bulandshahar District, Uttar Pradesh as influenced by irrigation with mixed industrial effluent of various industries was carried out by Kumar et al (1995). It is noted that indiscriminate disposal of the effluent from this industrial complex has aggravated the salinity and sodicity problem in the irrigated soils and shallow surface water resources like ponds. Organic carbon status of surface soils increased two to three times as compared to that of adjoining normal soils.

Sivakasi (Kamarajar district, Tamil Nadu) in an industrial area with a large number of industries, such as matches, fire-works, printing (litho and offset), printing ink and dye manufacturing, metal, chemical industries etc. The establishment of these industries is posing threat not only to the local atmosphere and soil but also to the quality of ground waters. The city's population mostly depends on the ground water for drinking and domestic needs. Venkatesh and others (1992) investigated ground water pollution potential of the mentioned area.

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However, the parametric ratios of the effluent are found to have no significant correlation with ratios of other waste samples, indicating a very little pollution potential of ground water due to chemical industry. Hence, the computation of parametric ratios and their respective correlation coefficients for ground water quality parameter can lead to useful qualitative conclusions, may be in due course due to prolonged exposure of the disposal of the effluents from the chemical factory, The high ash content of coal is one of the inherent disadvantages in coal-fired power generation. A small part of fly ash produced is utilized in some sectors, such as construction material, building engineering, road, backfill, agriculture, selective extracting and processing useful materials (Shao, 1992)

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The feasibility of fly ash as compared to lime to ameliorate the low pH of acidic coal mine spoils under controlled pot culture conditions are reported by Srivastava and Chhonkar (2000) using Sudan grass (Sorghum sudanens) and Oats (Avena sativa) as indicator crops. It is observed that at all levels of applications, fly ash and lime significantly increase the pH of mine spoils, available P, exchangeable K, available S and also uptake of P, K, S and oven-dried biomass of both these test crops. Fly ash and lime do not cause elemental toxicities to the plants as evidenced from the dry matter production by the test crops. The results indicated ~~that~~ fly ash to be a potential alternative to lime for treating acidic coalmine spoils. In a pot culture study (Lal et al, 1996) with acid Alfisol (pH 4.9) amended with fly ash, highest dry matter yield of soybean was obtained in treatment receiving 16% (w/w). Fly ash can supply the alkaline micronutrients like B, Cu, Fe, Mo, Zn. Sewage sludge on the other hand is acidic in nature and containing macronutrients like Ca, S, Mg, P, K etc. Land disposal of these wastes separately will cause problems like

- (i) Potential phytotoxicity from micronutrients excess (especially B)
- (ii) Shortage of essential major nutrients
- (iii) Nutrient deficiency caused by unfavorable fly ash pH and slow nutrient release.

Solid waste is a scourge in all-Indian mega-cities. The quantity of solid wastes generated in urban areas, ranges from 0.3 to 0.5 Kg/capita/day, depending upon the lifestyle of the people (Ahsan 1999). In Delhi alone, more than 6,700 tones of solid waste are generated every day (Indian Express, May 2004). An

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integrated solid waste management should include the following components; waste minimization, material recovery and recycling, waste processing and energy recovery, waste transformation and waste disposal. In India, the amount of waste generated per capita is estimated to increase at a rate of 1%–1.33% annually (Shekdar 1999). It is estimated that the total waste quantity generated in 2047 would be approximately above 260 million tonnes—more than five times the present level. This enormous increase will have significan~~ce~~t importance regarding its disposal. The burden that the increase in solid waste generation would impose, is evident from the fact that the cumulative requirement of land (base year 1997), for disposal of MSW, would amount to around 1400 km^2 by 2047 (Singhal ~~&~~ and Pandey 2001)

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In a study by Arora and Chhibba (1992), soils from the sewage-influenced areas of Ludhiana city was studied and found that it had lower pH, calcium carbonate and organic carbon content. While available Cu was distinctly higher in such soils, the percentage of Zn-deficient samples was much lower. In such areas the concentrations of Cu and Fe in the wheat leaves were higher while those of Mn and S were lesser but rice leaves had higher concentrations of Zn, Cu, Fe as well as Mn.

Irresponsible disposal of hazardous wastes may have severe impact on the safety and well being of employees as well as communities living as close proximity to the plant. According to Sharma (1993), any waste reduction technique will depend not only on the composition of the waste but also on the waste disposal system in addition to the environmental factors.

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The study of the solid wastes generated in Wazirpur Industrial Area (Giri and Bhattacharyya 1998) revealed the environmental problems associated with them. The fate of these solid wastes generated in the industrial area was critically examined with respect to topographic location, natural drainage systems, and present disposal practices of the industrial and residential units. The lack of public awareness continued to pl~~y~~ay havoc.

Sulfur, an essential plant nutrient, occurs in soil and aquatic systems in both organic and inorganic forms, major fraction being the organic form. Although, the total S content in soils varies depending on the nature of the soil; it is believed that most S in soils of humid and semi-humid regions exists in organic forms (Stevenson, 1994). For example, it was reported that organic S accounts for an average of 97% of the total S in Iowa surface soils (Tabatabai and Bremner, 1972a,b) and 93% of the total S in Australian soils (Freney, 1967). A study by Sharma et al (2001) has shown that in wet temperate zone the organic sulfur constitutes 48.4 to 67.7 % of the total sulfur. The S contents range from 0.1 to 3.6% in soil humic substances and from 0.5 to 1.43% in aquatic humic substances. The organic S in soil and aquatic systems is usually divided into two main groups of compounds, namely, S directly bound to C and sulfate esters (Freney et al,. 1970, Tabatabai and Bremner,1972a,b Stevenson, 1986; Germida et al., 1992,). Organic S that is readily reducible by HI to H_2S is interpreted as sulfate esters, while C-bonded S is estimated from the difference between total organic S and HI-reducible ester sulfate S. XANES (K Edge X Ray Absorption Near Edge Structural Spectroscopy) reveals that Sulfur in humic substances exist in four major oxidation group namely Sulfonate Easter, Sulfoxide, Sulfonate and Thiosulfide (Xia et al 1998).

The inorganic forms of sulfur are Sulfate, sulfide, sulfites etc; Sulfate is the most important form among them. Sulfur is primarily taken-up in the form of SO_4^2 anions. (Tisdale et al, 1998). Sulfur-enriched soils may be the result of natural processes like soils in the vicinity of volcanoes, S/CO_2 events and lignite burns, saline soils, heavy metal soils and acid sulfate soils or the result of man-made processes like soils in areas with high sulfur deposition as a result from SO_2-emission, tailings of coal and ore mines, and piles of flue gas desulfurization (FGD) by-products, industrial sludge depositions. In the natural situation sulfate does not accumulate in soils of the humid climatic zones. Due to leaching the annual loss of sulfate is estimated between 20 and 120 kg S ha-1 yr-1 (Schachtschabel et al.1992). Under arid conditions, however, sulfate can accumulate in the surface soil and finally precipitate as gypsum. In the case of gypsiferous soils, which cover 100 million ha in the world (Verheye & Boyadgiev 1997) two major nutrients, i.e. calcium and sulfate occur simultaneously in excess.

The deposition of SO_4^{2-} is not only important because of the associated acidity (H^+) but also because SO_4^{2-} anions facilitate the leaching of cations. Sulfate is a relatively mobile anion and can accompany cations exchanged into solution from either vegetation or soil particle surfaces by H^+ ions from deposition (Johnson and Cole. 1977). Sulfate deposition can therefore enhance the leaching of cations, both acid ($H^+$and Al^{3+}) and base cations e.g. Ca, Mg, K, & Na (Cronan et al 1978, Johnson and Cole, 1980, Singh et al, 1980, Foster et al 1989,David et al 1991a). The base cations are also major plant nutrients. The leaching from foliage (which are initially derived from the soil) and the soil due to the deposition of SO_4^{2-}anions therefore results in both acidification and loss of fertility of the soil.Since sulfate in soil solutions and surface waters serves as the dominant counter-ion for cations such as H^+ and Al^{3+}, processes that mobilize or immobilize sulfate also affect these constituents (Cole and Johnson, 1977; Likens et al., 1977).

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The biological conversion of SO_4^{2-} to organic S, results in the removal of SO_4^{2-}anions from solution and thereby reduces cation leaching However upon mineralization of the organic S, the original SO_4^{2-} and associated acidity (H^+ ions) are returned to the soil solution. Another important process by which SO_4^{2-}anions are removed from the soil solution is through sulfate adsorption. Sulfate adsorption is, however, partly reversible (Harrison and Johnson, 1992: Carlton, 1995; Gobran et al, 1998). Lowered soil solution SO_4^{2-} concentrations and increased pH, would therefore tend to result in the desorption of previously adsorbed Sulfate and the release of the associated acidity, This may be an important process of controlling, and how soils respond when atmospheric inputs decrease (Harrison and Johnson. 1992; Bishop et al, 1995). Plant absorbs sulfur (S) from the soil solution primarily as sulfate. However, soluble and adsorbed sulfate comprise less than 10% of the total topsoil S under New Zealand pasture (Parrott and Sarathchandra 1987). The rest is incorporated predominantly in organic combination (Perrott and Sarathchandra 1987), since any naturally occurring inorganic compounds of S from the S cycle; such as sulfite, thiosulfate, and elemental S, exist at concentrations of 1 mg/kg S or less in well-drained pastoral soils (Lee et al 1992; Watkinson and Kear 1994). For most soils, particularly those deficient or marginly deficient in S plants annually absorb considerably more S than the amount of sulfate in the surface soil at any particular time (Hoque et al 1987). For instance Ledgard et al, (1991) found that S uptake by pasture to be up to 5 times the amount of sulfate in the soil. In the absence of external and subsoil inputs, this extra sulfate absorbed by plants derives from the net excess of microbial mineralization of soil organic-S over immobilization, and leaching of sulfate (Watkinson-and Perrott 1990), where soil sulfate at any given time is insufficient to sustain desired growth (Sinclair et al. 1985), additional S may be supplied as fertilizer.

Acid deposition in Sweden consists almost entirely of H_2SO_4 (c.70%) and HNO_3 (c. 30%) Because the bioaccumulation of S is low compared with that of N, SO_4^{2-} becomes the dominant anion associated with acid input in the soil solution. For a number of reasons, it is very important to know the fate of SO_4^{2-}- when assessing the effects of acid input in the soil. Anion mobility is a key factor determining the effects of acidification in soils. Since cations cannot be leached out of the soil system unless an equivalent amount of anion is present in the soil solution, the retention of anions diminishes leaching of base cations as well as of Al^{3+} and H^+. Sulfate can be adsorbed by aluminum and iron hydrous oxides in acid soils (.Johnson & Todd, 1983; Singh, 1984; Fuller et al., 1985). The adsorption of SO_4^{2-} by soil is strongly related to the content of iron (Fe) and aluminum (Al) oxides and is an important process in the illuvial B-horizon of podzolic soils (Johnson, 1980; Johnson and Todd. 1983: Singh. 1984, Karlton and Gustafson, 1993; Singh et al. 1980: Gustafson and Jacks. 1993).

Although the mechanism of SO_4^{2-} is still not fully understood, it is known that the process also involves the adsorption of H^+ ions (Hingston et al., 1972), Thus, SO_4^{2-}, adsorption acts as a pH buffer mechanism and implies storage of acidity.

Numerous extractants have been suggested for estimating 'available' soil Sulfur (Beaton et al, 1968), but there is no general agreement on which estimate best defines a soil's Sulfur supply. The system is complex because soil organic Sulfur may mineralize and in the field Sulfate can leach and plants may take up Sulfur from sub-soil horizons. Furthermore, the importance of Sulfate sorption by soil on S nutrition of plants, reported by Barrow (1964), largely seems to have been ignored by others. Williams and Steinbergs (1964) have shown that adsorbed Sulfate is an available source of Sulfur for plants and thus only those extractant that recover this fraction from soil can be expected to measure 'available S'. It is generally accepted that phosphate solutions displace sorbed Sulfate. In non-acid soils, Sulfate sorption is unimportant and the phosphate extractant remove no more Sulfur than do solutions of LiCl, $CaCl_2$ (Tabatabai, et al 1972), but in acid soils the phosphate extract-ants remove more Sulfur than do water and chloride extraction. Other extractants such as the acetates and sodium bicarbonate are recognized as measuring some soil organic S as well as Sulfate; the amount extracted depending partly on the pH.

Freeney et al(1968) have shown that ^{35}S- sulfate can be incorporated into soil organic fraction as a result of microbial activity concurrently with a net mineralization. In such a dynamic system it is unlikely that any extractant can do more than indicate the S supply of a soil at a particular time. However it is important to know whether the fractions of soil S extracted by the various methods are related to that used by plants

The capacity of soils to sorb sulfate varies widely with soil properties, being highest where there are substantial amounts of aluminum and iron oxides and of allophanic constituents (Parfitt, 1978). Thus, Andosols and other variable charge soils usually sorb considerable amounts of SO_4^{2-}- and this may have important effects on plant nutrition (Barrow, 1970). Several models have been proposed to account for the sorption of SO_4^{2-} in soils and soil materials. Some studies have concluded that, like phosphate, SO_4^{2-} is sorbed by a ligand exchange mechanism (Gebhardt & Coleman, 1974; Parfitt & Russell, 1977; Parfitt & Smart, 1978; Zhang el al., 1987; Marcano-Martinez & McBride, 1989). Ligand exchanges take place between SO_4^{2-} and both OH^- and OH_2 (Curtin and Syers, 1990; Guadalix and Pardo, 1991). Release of OH^- ions during SO_4^{2-} sorption and an increase in the negative charge of the sorbing surfaces has been regarded as evidence for this conclusion. Parfitt & Russell (1977) and Parfitt & Smart (1978) proposed that SO_4^{2-} was sorbed as a binuclear bridging complex on iron oxides; and Rajan (1978, 1979) suggested the formation of a six-membered ring. However, there are certain differences between phosphate and SO_4^{2-} sorption. Sulfate is sorbed by soils less strongly than phosphate (Parfait, 1982) and the process is more strongly pH-dependent (Barrow, 1970; Bolan el al., 1986; Nodvin et al., 1986). Ryden et al (1987) have shown that sorption of $SO_4^{2-}$by a ferric oxide gel was completely eliminated when this anion was added together with equimolar amount of H_3PO_4 suggesting that SO_4^{2-} docs not compete effectively with phosphate for the sorption sites and also with the well known weak ability of SO4 to compete with organic anions for sorption sites (Kaiser and Zech, 1999;).

The adsorption of SO_4^{2-} by soils is an important soil chemical process that influences the effects of acidic deposition in terrestrial ecosystems. Since the adsorption of $SO_4^{2-}$by soils or solid phases common in soil., often results in the release of OR- (Rajan, 1978; Parfitt and Smart, 1978; Chao et al., 1965) it is presumed to be an important mechanism for reducing the transport of H^+, $Al^{3+,}$ Ca^{2+}, Mg^{2+}, Na^+ or K^+ through soils. The amount of OH^- released during SO_4^{2-}adsorption depends on -the characteristics of the adsorbent, the amount of SO_4^{2-} already adsorbed and the solution pH. Rajan (1978) and Parfitt and Smart (1978) proposed the hypothesis that ligand exchange of SO_4^{2} $^-$for OH^- or H_2O occurs at surfaces of oxides of Fe and Al. Rao and Sridharan (1984) suggested that Sulfate adsorption on Kaolinite occurs by a similar mechanism releasing either OH^- or H_2O depending on the surface charge of Kaolinite edge sites. Chao et al, (1965), Gebhardt and Coleman (1974)), Parfitt and Smart(1978); and Johnson et al, (1980) have also suggested that soil adsorbing Sulfate releases 1 to 2 moles of OH^- per mole of sulfate adsorbed. Although the mechanism of SO_4^{2-} is still not fully understood, it is known that the process also involves the adsorption of H^+ ions (Hingston et al., 1972),

Anions adsorption is often categorized into two mechanism: (I) non specific adsorption, where the adsorbate is generally thought to be hydrated and retained by electrostatic forces in the outer Helmholtz plane, and (ii) specific or chemisorptions, where the anions are bound by covalent or vanderwaal forces in the inner Helmholtz plane (Hingston, 1981). All anions can be non-specifically adsorbed on the positively charged sites, but only a few (e.g. sorbed SO_4^{2-} and PO_4^{3-}) are subject to specific adsorption (Hingston et al 1967; Johnson and Cole 1977: Bohn et al, 1979)

Harward of Oergon State university and Reisenauer of the Unversity of California has summarized the mechanism of sulfate retention as:

1. Anion exchange caused positive charge developed on the hydreus iron and aluminum oxide or on the crystal edge of clays especially Kaolinite, at low pH value.
2. Retention of sulfate ions by hydroxy-aluminum complexes by coordination. Salt adsorption resulting from attraction between surface of colloids and salts

3. Atmospheric properties of soil organic matter, which develop positive charges under certain conditions.

Workers in Virginia have shown a mechanism that account for the adsorption of sulfate. They assume a homoionic aluminum –saturated clay of hydrated oxides R (iron and Aluminum).

$$yK + Al_x[clay] + y\,H_2O \rightarrow Al_xK_y[clay] + y\,H$$

$$SO_4^{2-} + R_x(OH)_y[clay] \rightarrow R_x[(OH)_{y-z}(SO_4^{2-})] + z\,OH^-$$

The mechanism was able to explain several phenomenon e.g. sulfate adsorption is increased as pH is lowered because the replaced OH^- ions are more effectively neutralized. Increased Cation affinity causes the replacement of more aluminum and causes more hydrolysis.

Curtin & Syers (1990) concluded that the Sulfate anion may not be chemisorbed as is commonly supposed; they used the term 'low-affinity specific adsorption', proposed by Uehara & Gillman (1981), to distinguish a situation in which the sorbed anion does not become chemically coordinated with the surface metal atoms.

The capacity of a soil to sorb sulfate is an important factor which influences sulfate leaching and hence the availability of sulfur to plants. Soils vary in their sorption capacity for sulfate and sulfate sorption is affected significantly by management practices, such as lime and phosphate addition. Sulfate is sorbed by soils less strongly than phosphate (Hasan et al., 1970; Haque and Walmsley, 1973) and more strongly than nonspecifically sorbed anions, such as chloride (Hingston et al., 1972). The strength of retention decreases in the order hydrodoxyl > phosphate > sulfate =acetate > nitrate = chloride (Bingham et al . 1965; Chang & Thomas , 1963; Chao et al., 1964).

Factors affecting Sulfate adsorption include pH (Jaggi et al 1999, Parfitt, 1982, Kamprath et al. 1956), type of cation present (Chao et al., 1963), presence of competing anions (Chao, 1964; Parfitt, 1982), extractable Al and Fe fractions (Chao et al., 1964; Barrow, 1967; Singh, 1980; Johnson and Todd, 1983; Fuller et al., 1985), extractable Sulfate (Metson and Blakemore, 1978), organic Carbon (Jaggi et al 1999, Singh, 1984; Evans, 1986), clay content (Chao et al. 1962), and soil horizon type (Singh, 1980; Johnson and Todd. 1983; Fuller et. al., 1985; Weaver et al.; 1985).

Guadalix (1991) showed that the amount of surface charge (negative) increased with pH and the surface positive charge decreased with increasing pH, but even at pH 7 the soils contained appreciable amounts of positive charge. This apparent co-existence of both types of charge is consistent with the suggestion that positive and negative charges are spatially separated on soil colloids and do not neutralize each other (Espinoza et al., 1975; Black & Waring, 1976. 1979). Sulfate adsorption generally increases when the system is artificially acidified, which is related to the increased positive surface charge that variable-charged soils acquire as pH decreases (Chaos et al., 1964; Zhang et al., 1987;). The low or negligible positive surface charge present in basic soils would explain their poor Sulfate sorption (Marsh et al, 1987). MacDonald and Hart (1990) found a significantly negative relationship between sulfate sorption and soil pH when working with surface horizons of soils from the lower peninsula of Michigan with a wide range of soil pH-H_2O (5.1-8.4). More recently, MacDonald et al. (1994) observed a significant negative relationship between Sulfate sorption and soil pH when studying soils from a wider area in the Great Lakes region with a range of pH-$CaCl_2$ from 3.6 to 8.0.

Sulfate adsorption in soils is mainly associated with Al and Fe oxy-hydroxides and with allophanic constituents (Chao et al., 1964; Parfitt, 1978), compounds all characterized by having a pH-dependent surface charge. Anion adsorption has also been associated with the presence of Al-humus complexes and, to a lesser extent, with Fe-humus complexes (Wada and Gunjigake, 1979; Shoji and Fujiwara, 1984). The relations between pH, different fractions of Fe and Al and $Na_4P_2O_7$-soluble Carbon and the amount of adsorbed SO_4^{2-} were assessed by Karltun et al (1993). It was found that, as the proportion of organically complexed Fe and Al increases, the ability of soil to adsorb Sulfate decreases. It was concluded that Fe and Al associated with organic matter cannot adsorb Sulfate and that the degree of this association is pH dependent. The amount of Sulfate retention is affected by the associated cation of the salt or the exchangeable cation. The effect follow a lyotropic series i.e. $H+ > Sr^{+} > Ba^{2+} > Ca^{2+}\ Mg^{2+} > Rb^{2+} > K^{+} > NH_4^{+} > Na^{+} > Li^{+}$ (Chao et al, 1963; Camps et al, 1999) observed that SO_4^{2-} sorption increased with increasingly high concentrations of SO_4^{2-} added. Adsorbed Sulfate is in kinetic equilibrium with the sulfate ions in solution (Chao et al 1962a). The sulfate adsorption is dependent upon the type of clay minerals, clay content as well as the type of the soil horizons. The adsorption increases with the increase in the clay content of the soil. Capacities of hydrogen saturated clays for sulfate adsorption are in order Kaolinite >Illite > Bentonite (Tisdale, et al 1998). It is possible that when equilibrium SO_4^{2-} levels are high enough, the Kaolinite surface could act as a nucleus for crystal growth of basic aluminum sulfate minerals such as alunite, jarbanite, or basaluminite (Adams and Rawajfih, 1977). Camps et al (1999) concluded that sorbtion decreases in the order: ambphibolite > biotic schist > Granite > phyllite. Allophane is not only associated with high organic-S levels, but also retains sulfate strongly against leaching, so that, as a soil group, yellow-brown loams are not S-deficient. In contrast, yellow-grey earths are seasonally dry, have a much lower allophane and organic matter content, and are frequently S-deficient (Watkinson (1996). The capacity of soil to adsorb sulfate also vary with the depth or horizons. The amount of sulfate adsorbed may be low in surface horizon but are often grater in the lower soil horizons. The capacity for sulfate adsorption is often greater in subsoil due to presence of more clay and Fe as well as Al oxides, organic ligands present in soil solutions may play an important role in determining the SO_4^{2-} adsorption capacity of soils and the subsequent amount of OH released. Several references have been made to the possible role of organic ligands in competing for SO4 adsorption sites (Krug and Frink, 1983; Johnson et al., 1980; Fuller et al., 1985). Humic and tannic acids inhibited the adsorption of S04 by kaolinite at total soluble C (Concentrations) levels ranging from 1.4 to 3.6 mM (Inskeep 1989). Similar observation has been found with citric acid, gallic acid and oxalic acid. Increase in the concentration of DOC (Dissolve Organic carbon) induced the net release of sulfate in the soil horizons. The DOC concentrations strongly decreases in contact with mineral soil horizons (McDowell and Likens, 1988; Guggenberger and Zech, 1993) by sorption on Al and Fe oxides/hydroxides and clay minerals (McDowell And Wood 1984, Jardine et al 1989; Moore et al., 1992).

Organic acids and humic substances adsorb to positively charged surface sites of iron oxides and Kaolinite (Parfitt et at, 1977a,b; Tipping, 1981). Sorption of DOC on oxides/hydroxides seems to involve a Ligands exchange mechanism by which hydroxyl and carboxyl groups displace OH^- and OH_2 from the surface of Al, Fe, and Mn oxides/hydroxides (Tipping, 1981:Tipping And Heaton 1983, Davis 1982, Gu et al 1994, Ochs et al 1994).

Organic acids and humic substances adsorb to positively charged surface sites of iron oxides and Kaolinite (Parfitt et at, 1977a,b; Tipping, 1981). Presumably, any adsorption of organic acid would reduce the number of effective sites available for SO_4^{2-} i.e. a Competitive adsorptions between inorganic anions and organic acid have been observed. The probable functional groups responsible for binding of organic acids to AlO were R-COR, R-OH, or RCOOH. Consequently, it is expected that the amount of ionized or the total number of these functional groups present in an adsorption experiment would relate to the extent of adsorption inhibition (Inskeep,1989)

The SO_4^{2-} anions facilitate the Leaching of cations; Sulfate is a relatively mobile anion and can accompany cations exchanged into solution from either vegetation or soil particle surfaces by H^+ ions from deposition (Johnson and Cole. 1977). It causes the leaching of cations, both acid (H^+ and Al^{3+}) and base cations e.g. Ca, Mg, K, & Na (Cronan et al 1978, Johnson and Cole, 1980, Singh et al, 1980, Foster et al 1989,). The base cations are also major plant nutrients. The leaching from foliage (which are initially derived from the soil) and the soil due to the deposition of SO_4^{2-}anions therefore results in both acidification and loss of fertility of the soil.

The adsorption of base cations in the mineral soil is also related to the adsorption of SO_4^{2-}. By removing SO_4^{2-} ions from the soil solution,anions, necessary to accompany cations are reduced and therefore base cations are withdrawn from' solution (Johnson and Cole. 1977: David et al., 1991 a). These base cations could be retained by exchange sites or taken-up by roots. The significant positive correlation between the output of SO_4^{2-} and the sum or base cations from below each soil' horizon suggested that SO_4^{2-} is important in controlling the leaching off,

Base cations even though SO_4^{2-} anion balanced less than 50% of the base cation charge in the O and E-horizons. Sulphate anion balanced nearly all the basic cation leaching from below the B-horizon. Organic anions were probably also important in the leaching of base cations from the O and E-horizons. Krug and Isaacson (1984) and Lundstrom (1993) have shown that there is greater leaching of organic acids from the O-horizon than from the mineral soil horizons of podzolic soils. (Pharainen(2002). Potentially it may include the total organic-S Sulfate and organic S in pastoral soils. But comprising fractions having varying rates of mineralization (Watkinson and Perrott, 1990) they proposed that the most readily available organic-S for microbial attack would be the fraction in soil solution. The data of Maynard et al (1987) showed that several weakly buffered, dilute salt solutions of similar ionic strength but different composition extracted similar small amounts of organic-S from the organic horizon of forest soils. This fraction would probably be an estimate of the most labile form of organic-S in the soil, and includes that in the soil solution.

Organic Sulfur plays an important role in the complexation of toxic trace metals. Humic substances are major components in natural organic matter and play an important role in controlling transport, speciation, fate, and bioavailability of inorganic and organic contaminants in the ecosystem (Stevenson, 1994: Weber, 1988; Murphy and Zachara, 1995; Harter and Naidu, 1995). Although Sulfur occurs in relatively small concentration compared with O and C (Malcolm, 1990), S-containing functional groups in humic substances may play a disproportionate role in complexing certain trace metals. These metals include Cd, Co, Ni, Pb, Zn, and Hg and are classified as "soft " or "borderline" metals by Misono et al. (1967). Theoretical calculations by McKnight (1994) suggest that the incidence of metal-binding sites for functional groups containing Sulfur is comparable to that of strong metal binding. Sites even if only one-half of the functional groups that contain S are considered. Recent x-ray absorption fine structure spectroscopy (XAFS) studies of the structure of the binding environment of Zn and Hg complexed with soil humic substances suggested the involvement of S-containing functional groups in the complexation of these elements (Xia et al. 1997).

Volatile sulfur compounds are produced through microbial transformations of soil sulfur compounds under both aerobic and waterlogged conditions. Four of these soils, however, also released volatile sulfur compounds when incubated aerobically. Where volatilization occurred, the volatile sulfur detected was diethyl sulfide (CH_3SCH_3) alone or diethyl sulfide accompanied by smaller quantities of carbonyl sulfide (COS), carbon disulfide ($CS_{2=}$), methyl merchantman (CH_3SH), and/or diethyl disulfide (CH_3SSCH_3). Diethyl sulfide accounted for 55 to 100% of all sulfur volatilized. No release of volatile sulfur was detected from this group of Iowa soils when there was less than 2.0% organic matter. However, volatilization occurred in five out of the six soils containing more than 5 to 7% organic matter. The actual amounts of sulfur volatilized were very small and did not represent more than 0.05% of the total sulfur present in soil.

Photo-remediation is mainly discussed in relation to the removal of heavy metals from the environment by plants (Salt et al.1995) ranging from photo-stabilization of a site into immobilization and extraction of the element nutrient. In areas with higher concentration of however, the uptake of sulfate by roots is diminished upon exposure of the shoot to SO_2 (Rennenberg & Polle 1994) due to a leaf-guided feed-back mechanism. In the case of gypsiferous soils, sulfur contents of extractor plants can easily exceed 1% sulfur in the dry matter: Gypsophila species are well adapted to gypsiferous soils and may be good sulfur extractors (Duvigneaud & Denaeyer-De Smet 1968), but their low biomass (Fiedler et al. 1987) will demand a similar transfer of genes to higher reproductive plants as proposed for metal-hyperaccumulators (Ebbs et al.1997). The low nitrogen content of most soils with increased sulfur content, however, may hamper the growth rate of plants so that the annually harvestable biomass remains low. (Ernest ,1998), Higher plant species have a high biodiversity with regard to the sulfur metabolism and the handling of a surplus of sulfur. In western European countries has diminished the enrichment of sulfur in the soils to such a degree that sulfur-demanding crops suffer from Sulfur deficiency if not fertilized. In eastern European countries the implementation of clean-up technologies for SO_2 emission will diminish SO_2 damage to crops, sulfur deposition on soils and sulfur accumulation in crops so that the present problems (Mikula 1995) can be solved; if sulfur fertilizer is not supplied in time, subsequently similar problems may arise concerning the sulfur supply to agricultural crops as nowadays experienced in western Europe. Phytoremediation of sulfur-enriched soils may only be effective in gypsiferous and acid sulfate soils due to the millions of hectares involved. Prior to phytoremediation a balance has to be made between sulfurization of the soil by evapotranspiration and desulfurization by plants. Unfortunately, So far, the research on the chemical dynamics of these sulfur-enriched soils and on the uptake of sulfur by plants at such sites is not sufficiently consistent to establish such a balance (Konsten et al. 1994; Carvalho & Van Raij 1997; Pearce & Sumner 1997). The implementation of desulfurization of sulfur-enriched soils by plants, is mostly not hampered by the sulfur content of the soil, but by the surplus of other chemical elements which affect plant growth more than sulfur. In acid sulfate soils liming can diminish the bio-availability of the accompanying elements; liming will increase the pH so that the formation of gypsum will be unlikely. Generally, phytoremediation is still early stage of, lot of scientific and processing problems have to be solved prior to bring phytoremediation of sulfur-enriched soils.

Chapter III

Materials and Method

3.1 SAMPLE COLLECTION

3.1.1 SOLID WASTE

Study area: Wazirpur Industrial Area, which is situated in Northwest part of Delhi covers an area of 210 acres, (*figure 3.1*). Northwestern ring road system surrounds this highly polluted area It is surrounded by residential areas such as Shalimar Bagh , Ashok Vihar Azadpur Sabzi Mandi , Model Town, etc.

Initially this area had approximately 1665 industries among which only 424 were registered. But after 1998, as per strong recommendation of CPCB and DPCC a lot of unregistered industries are closed. The main polluting industries, which are still in working condition, are electroplating, rolling-pickling and textiles. The others are rubber, plastic, soap, electronic goods etc. Due to its large number of small-scale industries and their unmonitored level of pollution, now Wazirpur has emerged as one of the major polluted industrial zones of Delhi.

The entire area is divided into three industrial parts A, B and C (Map 3.2). Due to its industrial units, every day a huge amount of toxic wastes are spewing out of those units.

The hazardous effluents are governed by strong acids like HNO_3, H_2SO_4, HF, HCl and coating materials like chromium, zinc blend, bleaching powder, and iron pieces, used as raw material in the electroplating, rolling & pickling and textiles industries. Though some of these industries are closed by CPCB, this area does not have a sound and satisfactory waste disposal system. Major health problems occurring here are due to dumping and delayed disposal of the solid waste.

Collection of the solid waste: Ten Sampling sites were decided in each of the block (Block A , B and C) which consists of road side dumps as well as a common open dumping place. The waste samples were collected from each of the sampling site by removing the upper superficial layer to 30 cms of depth. The collection was done in three consecutive layers in order to make a true representative sample. The collected samples were kept in airtight polythene bags. The samples were collected in each season namely Winter, Summer and Monsoon. The Frequency of sampling was as follow:

Collection of Solid waste	Date of sampling
Winter Waste	03/03/03
Summer waste	14/05/03
Monsoon waste	04/08/03

3.1.2 SOILS

Study area: The two sampling sites for soil are JNU Nursery and Chhattarpur Farm. JNU is educational cum residential institution. Here no industrial, agricultural or such other activities are taking place. The JNU soil is taken as uncontaminated, while the Chattarpur soils are considered to be contaminated due to anthropogenic activities as well as from the Fly ash of nearby Badarpur Thermal Power Plant. (Delhi)

Collection of soils: The soils been collected from 5 different spots of JNU and Chhattarpur (Map.no.3.1) and homogenized separately. The soil samples were collected only once in the study

Soil Samples	Date of sampling
Chhattarpur Farm	01/06/03
JNU Nursery soil	25/05/03

and

3.2 PRESERVATION OF THE SAMPLES

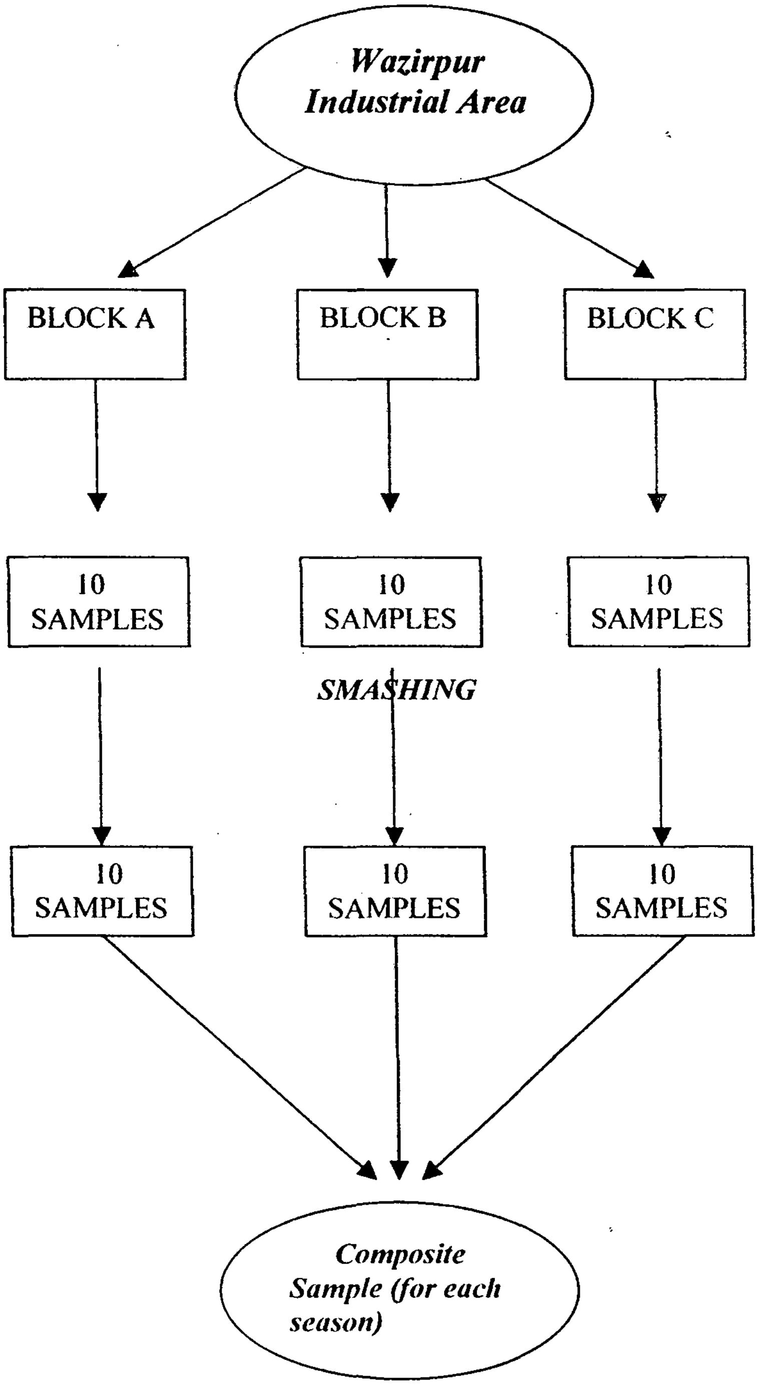
EC, pH & % Moisture Content of the samples (soil as well as waste) were determined immediately after collection and for other parameters both the soil and solid waste samples were first air-dried and then kept in airtight polythene bags in dark cold room (4 °C).

3.3 SAMPLE PROCESSING

ground

Both the solid wastes and soil samples were air-dried and then grinded by mortar & pestle and sieved using 2mm sieve. Solid waste samples of pH less than 3.5 of each

FLOW DIAGRAM OF SOILD WASTE PROCESSING



season were taken and homogenized to make respective composite samples by *Quadrate System.* These representative samples were kept in airtight polythene bags in the dark cold room at 4°C.

3.4 EXPERIMENTAL BOTTLE PREPARATION

In order to prepare experimental bottle, composite JNU & Chhattarpur soil samples were mixed separately with different percentage (10%, 20% and 30%) of composite solid waste of each season (Monsoon/Winter/Summer) by quadrate system. The wastes were lime treated (0%, 0.5% and 1%) and then mixed with soil and 50% water-holding capacity of the thus prepared soil mixture was maintained by adding known amount of distilled water. The water requirement of the prepared experiment bottle was calculated considering water holding capacity and % moisture content of the soils and solid wastes according to their amount present in each experimental bottle. A fixed amount (100gms) of the prepared samples was kept in small polythene bags in BOD incubator.

3.4.1 *Incubation of the experimental bottle:* The polythene bags were kept in BOD incubator at 28°C. The moisture of the experimental bottles was maintained by adding distilled water everyday. For analysis of pH, EC, CEC, Organic Carbon, Plant Available Sulfur (Sulfate), Total adsorbed sulfate, and Total sulfur, the incubated samples were taken from the bottles after 0, 10, 20, 30, 45, 60, 90 & 120 days of incubation.

3.4.2 Preservation of incubated samples: The incubated samples were taken from the experimental bottles and filling in small airtight polythene bags then kept in the dark cold room at 4 °C.

3.5 INSTRUMENTATION & REAGENTS USED

The instrument used for pH measurement was Digital pH meter Manufacturer: - Widsons Scientific Works, Delhi model No DB1011

The instrument used for Electrical Conductivity measurement was Digital EC meter Manufacturer -Widsons Scientific Works, Delhi model No DC610.

The instrument used for CEC measurement was *Kjeldahl Macro distillation assembly* Manufactured by JNU USIC

The spectrophotometer used for the purpose was UV 5704SS, manufactured by ECIL India.

All the chemical and reagent used, were of MERCK Ltd. Mumbai , India

3.6 ANALYSIS OF PHYSICO-CHEMICAL PARAMETERS

3.6.1 MOISTURE CONTENT

The moisture content of the soil/ samples at any time more or less depends on its water holding capacity and environmental condition with time. 10g of fresh solid wastes and soils (JNU and Chhattarpur) were kept in hot-air oven at 105 °C in clean-dry petri-dishes separately. After the time interval of 24, 48 and 72 hrs they were weighed. The moisture content is normally expressed in percentage on weight basis (g of water/100 g oven dry soil)

% of moisture on dry wt basis = $W_m X100/W_s$
Where, $W_m = W_i - W_s$
W_i= ***Initial weight of soil.***
W_s= *Dry weight of soil* **(NCERT-1985).**

3.6.2 WATER HOLDING CAPACITY

Water holding capacity is defined as the maximum amount of water a freely obtained sample can hold. It depends upon the soil texture pore sizes etc. The water is held in the soil pores with varying degrees of tenacity depending on the amount of water present in the size of pores

Procedure: About 20g of processed soil sample (each of JNU & Chhattarpur) and solid wastes (summer, monsoon, winter) were flooded for 2 hrs in 100 ml beakers separately. The water –soil suspension was filtered for the last drop of water using filter paper (*Whattman-1*), 10g of these saturated soils in previously weighed petridishes were kept in a hot air oven at 105°C and weighed after 24, 48and 72 hrs. The WHC is measured in % of the soil/sample weight.

$$\text{Weight \% of WHC} = \frac{(\text{Water saturated soil} - \text{Oven dried soil})\,X100}{\text{Oven dried soil}}$$

3.6.3. ELECTRICAL CONDUCTIVITY (EC)

Electrical conductivity of a solution is the conductance of the solution at 25°C temperature between electrodes 1 cm sq. and 1 cm apart. It measures the dissolved salts in a soil solution (*Holden, 1970*). Conductance is the reciprocal of resistance and is measured in 'Siemens' (mhos). For soil solution it is more usual to express results of conductivity as millisiemens per cm (*Hesse, 1972*).

Ref. missing

Missing in Ref ?

Properties of Normal Soil compared to Acidic, Saline, Sodic and Saline sodic Soils (After, Brady, 2000).

Sr. No.	Soil	Common pH	Common EC (mS/cm)
1	**Normal**	**6.5-7.2**	**≤4**
2	**Acidic**	**<6.5**	**<4**
3	**Saline**	**<8.5**	**>4**
4	**Saline sodic**	**<8.5**	**>4**
5	**Sodic**	**>8.5**	**<4**

Conductivity depends on dilution of the sample. However sample/water ratio is 1:5, 1:10 are most common for conductivity study to reduce microbial influence. A solution of soil and double distilled water is made in the ratio of 1:10 in a 100 ml beaker by stirring it with a magnetic stirrer for 10 minutes. EC values were measured after half an hour using an Electrical-conductivity meter after standardization.

EC is expressed as

C= 1/R *Where C= Electrical conductance in mS/cm.*

R = Resistance

3.6.4 pH

Sorenson's (1909) defined the pH as the negative logarithm of the hydrogen ion concentration, that is, $pH = log\ 1/ a^{H+} = -log\ a^{H+}$. It is one of the most indicative measurements of the chemical properties of the soil whether a soil is acidic, neutral or basic has much to do with the solubility of various compounds, the relative bonding of ions to exchange sites and the activity of various micro-organisms.. It has been observed that three soil pH ranges are particularly informative: a pH<4 indicates the presence of free acids generally from oxidation of sulfides ; a pH < 5.5 suggest the likely occurrence of exchangeable Al and a pH 7.8 to 8.2 indicates the presence of $CaCO_3$.(*Thomas ,1967*)

Ment in Refrences

The measurement of pH is normally done by either a colorimetric or an electrometric method. In present study case electrometric methods have been followed. This involves a glass H^+ sensing (indicator) electrode (Calomel electrode) paired with a reference electrode attached to a suitable meter for measurement of electro motive force, which is found to be proportional to pH. The calomel electrode contains a saturated KCl bridge that contacts the soil suspension and has a characteristic potential (voltage) relatively independent of H^+ activity. A solution of soil and double distilled water is prepared in the ratio of 1:10 in a 100 ml beaker by stirring it with a magnetic stirrer for 10 minutes and pH values were measured after half an hour using a pH meter after standardization.

3.6.5 ORGANIC CARBON

Organic matter influences physical and chemical properties of soils far out of proportion to the small quantities present (Balestent et al., 1988). Organic matter is an index of productivity of soil. . It also influences various physio-chemical properties such as infiltration and retention of water, degree of aggregation and overall structure that affects the air and water relationships, cation exchange capacity, soil color, which in-turn affects temperature relationship and adsorption and deactivation (or both) of agricultural chemicals. In poorly drained soil, because of their moisture content and relatively poor aeration, are generally much higher in organic matter (Nichols, 1984).

Miss Ref

Miss Ref

Principle: As per procedure given by Walkley and Black (1934) the soil or solid waste were digested with potassium dichromate and sulphuric acid to oxidize the humus.

$$2\,Cr_2O_7^{2-} + 3C^{\circ} + 16H^+ \xrightarrow{\Delta} 4Cr^{3+} + 3CO_2 + 8\,H_2O$$

The Heat of Dilution of Concentrated Sulfuric acid is used to drive the oxidation of C in organic matter to CO_2.

The excess of $Cr_2O_7^{2-}$ not reduced by sol, soil organic matter, is determined by titration with standard $Fe(NH_4)_2SO_4$ solution.

$$6\,Fe^{2+} + Cr_2O_7^{2-} + 14\,H^+ \xrightarrow{\Delta} 2\,Cr^{3+} + 6\,Fe^{3+} + 7H_2O$$

Orthophosphoric acid and NaF are added to Complex the Fe^{3+} ions if present so that it wouldn't interfere with the end point

Procedure: One gm of each sample was taken and shaken well with 10 ml 1N $K_2Cr_2O_7$ in 500 ml conical flask. Then with stirring 20ml of conc. H_2SO_4 was added in each sample & kept for 30 minute to complete the reaction. Then 200 ml -distilled water was added in each conical flask. Next 2 gram NaF and 10 ml orthophosphoric acid were mixed and stirred vigorously. Titration was done against 0.1 N ferrous ammonium sulfate in presence of diphenylamine as indicator. A blank in exactly similar way but without any soil (sample) was run.

Organic Carbon (%) = (3.951/ dry wt. of soil) X (1- T/S).
T=ml ferrous solution with sample titration.
S=ml ferrous solution with blank titration.
Organic matter (%) = Organic carbon (%) X 1.724.

3.6.6 CATION EXCHANGE CAPACITY

Cation exchange capacity (CEC) is "the sum total of the exchangeable cations that a soil can absorb" (Brady, 2000). A soil leached with salt solution has the power to absorb the cations of the percolating solution and liberate equivalent amount of other cations. The exchangeable form is the most important source of instantly available plant nutrient; in general 'available cation' can be considered as 'exchangeable' cation (Hesse, 1971). It depends upon various factors such as soil acidity type of soil presence of organic matter etc. The more clay and more organic matter in soil, the higher the CEC. Increase in soil acidity can decrease soil CEC and thus decrease the instant availability of the various cations (micronutrients) to plants soil quality (Brauer, 1999).

2/

Principle: A soil leached with a salt solution (1M) has the power to absorb the cations of the percolating solution and to liberate an equivalent amount of other cations. Thus the soil leached with 1N ammonium acetate (pH- 7) solution will absorb some ammonium ions and liberate calcium, magnesium, and other ions, which will appear in leachates. When the sample (ammonium saturated soil) is distilled in Kjeldahl flask and the distilled sample is titrated with 0.1 N HCl, gives the cation exchange capacity.

Methodology: Five gram of soil sample was shaken well in ammonium acetate solution and kept overnight, covered with a watch glass. Next day it was filtered with excess NH_4OAc (ammonium acetate, pH-7.0) and then washed with 95% ethanol till the filtrate shows the presence of NH_4 with Nesseler's reagent and left for half an hour to drop out ethanol. Now, the sample along with the filter paper in 400 ml double distilled water and 25 ml 45% NaOH was digested in Kjeldahl flask in presence of glass beads and liquid paraffin. About 200 ml distillate was collected in 20 ml 2% boric acid mixed indicator solution in a 250 ml conical flask and titrated against 0.1N HCl.

CEC= 10 T/ D. *Where,*

T= the volume in ml of standard acid after correction for blank.

D = dry weight (oven dry) of the soil sample.

3.6.7 SULFATE

Total Sulfate And Plant Available Sulfate

Total sulfate of the soil includes available sulfate as well as the adsorbed sulfate. It is considered to be weakly held as the strength of retention decreases in order Hydroxyl> Phosphate > sulfate =acetate> nitrate = chloride. The adsorption of the sulfate on soil depends upon various factor such as pH presence of another anions soil horizons and depth , organic matter , clay content etc.

Principle: As prescribed by M.A.Tabatabai, Chessnin and Yein, 1950, Combs J., J. Denning, K.D. Frank 1998,Sulfate is extracted from soil by extracting with a reagent, which has greater adsorption capacity to soil than it. The extractant of choice are Mono calcium phosphate, potassium monophosphate etc. The sulfate ions are precipitated as Barium sulfate and the turbidity produced is measured spectrophotometrically at 420nm.

When water is used as extractant, the soluble sulfate (plant available sulfate) is removed from the soil. When Potassium Mono-Phosphate is used as extractant, it removes sulfate adsorbed on the soil clay minerals along with the soluble sulfate.

adsorbed + soluble

Reagents

1. *Extracting reagent*

A. Potassium mono phosphate (PO_4^{3-} 500mg / ltr) for total sulfate

B. Distilled water is used in order to determine the water-soluble i.e. plant available sulfate.

2. *Seed solution*: 20 mg /ltr sulfate in 50% dilute hydrochloric acid in presence of a stabilizing reagent such as gum acacia or glycerol.

3. *Barium chloride crystals* : crushed to pass through as 20-to 30 mesh sieve.

4. *Sulfate standards* (1000mg S/ltr.): 5.434 gms of K_2SO_4 is weighed into 1,000 ml of volumetric flask and dissolved in distilled water. The stock was diluted to make standard of 0,10,20,30,and 40 mg S/ltr

4. *UV/VIS* Spectrophotometer set at the wavelength 420nm and cuvettes

Is it complete ?

Extraction procedure

ml

5 gms of air dry< 10 mesh (2-mm) soil into an 100 conical flask and 50 ml of the extractant and was shaked for 30 minutes.1/4 teaspoon of powdered charcoal was added and it was further shaked for 3 minutes. It was then filtered with Whattman 42 and the aliquot was transferred into another flask

Op

Analytical Procedure

1 ml of Acid Seed Solution was added to 10 ml of the aliquot in a 50 ml conical flask. It was swirled immediately and ¼ teaspoon (0.3-0.5gms) of Barium chloride was added and the content was stirred for about 1 minute. The turbidity generated was measured within time interval of five minutes.

Similar procedure was followed for sulfate standards. The value of absorbance obtained was plotted against the concentration to obtain standard series(calibration curve is linear up to 50mg S/lit)

3.6.8 TOTAL SULFUR

Principle

The total sulfur content of the soil was oxidized to Sulfate with suitable oxidizing agents Using the methodology as prescribed by Hesse P.R. (1972)

Reagents

Magnesium Nitrate solution – 25gms spec pure Magnesium metal was taken in a 1500cc volumetric flask and was added to it 500 ml of conc. HNO_3.it is diluted to 1500 cc. If the magnesium metal is not dissolve completely then another 50 ml of HNO_3 was added.

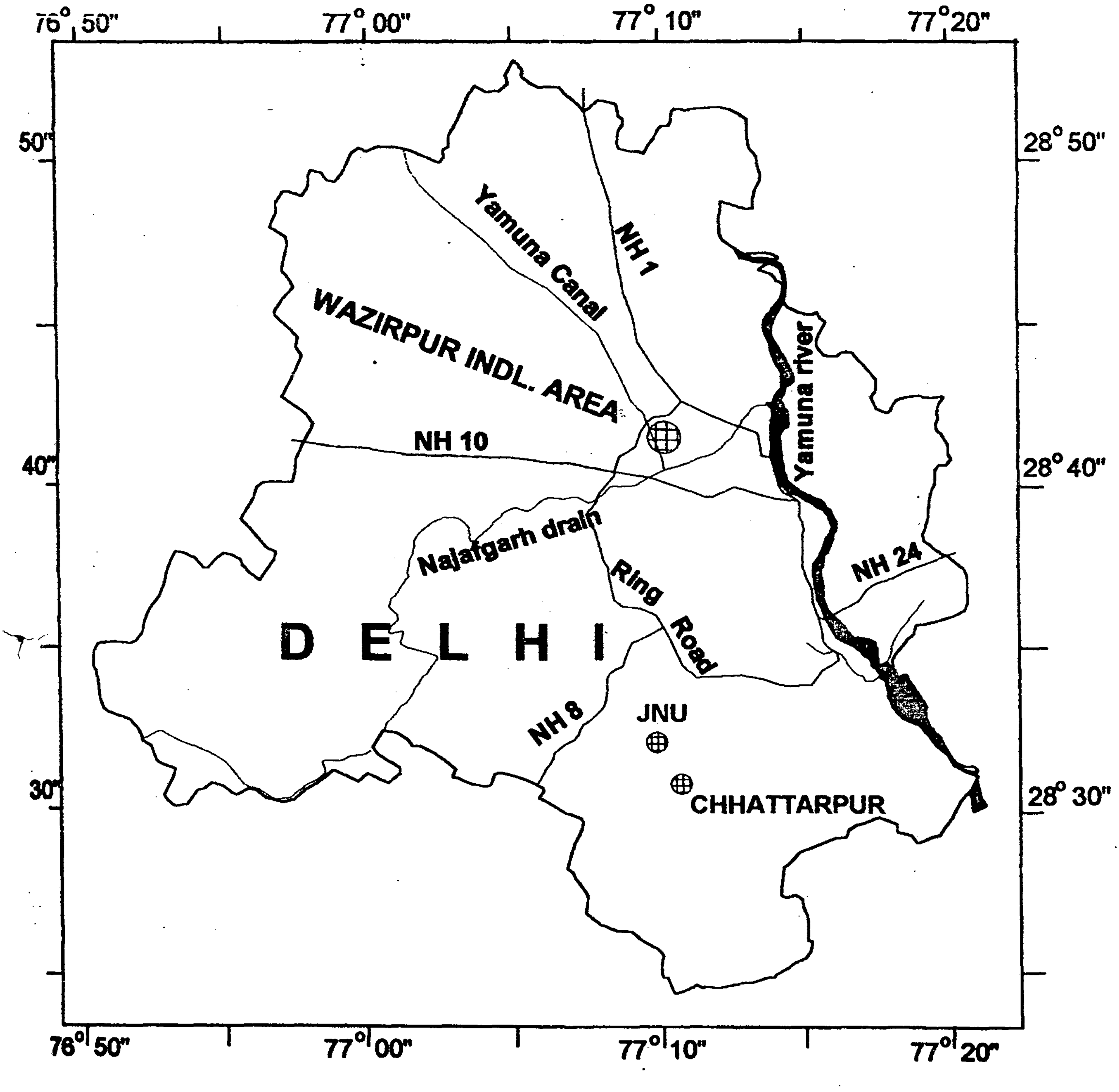
HNO_3 solution 25% v/v

Acetic acid 50% V/V

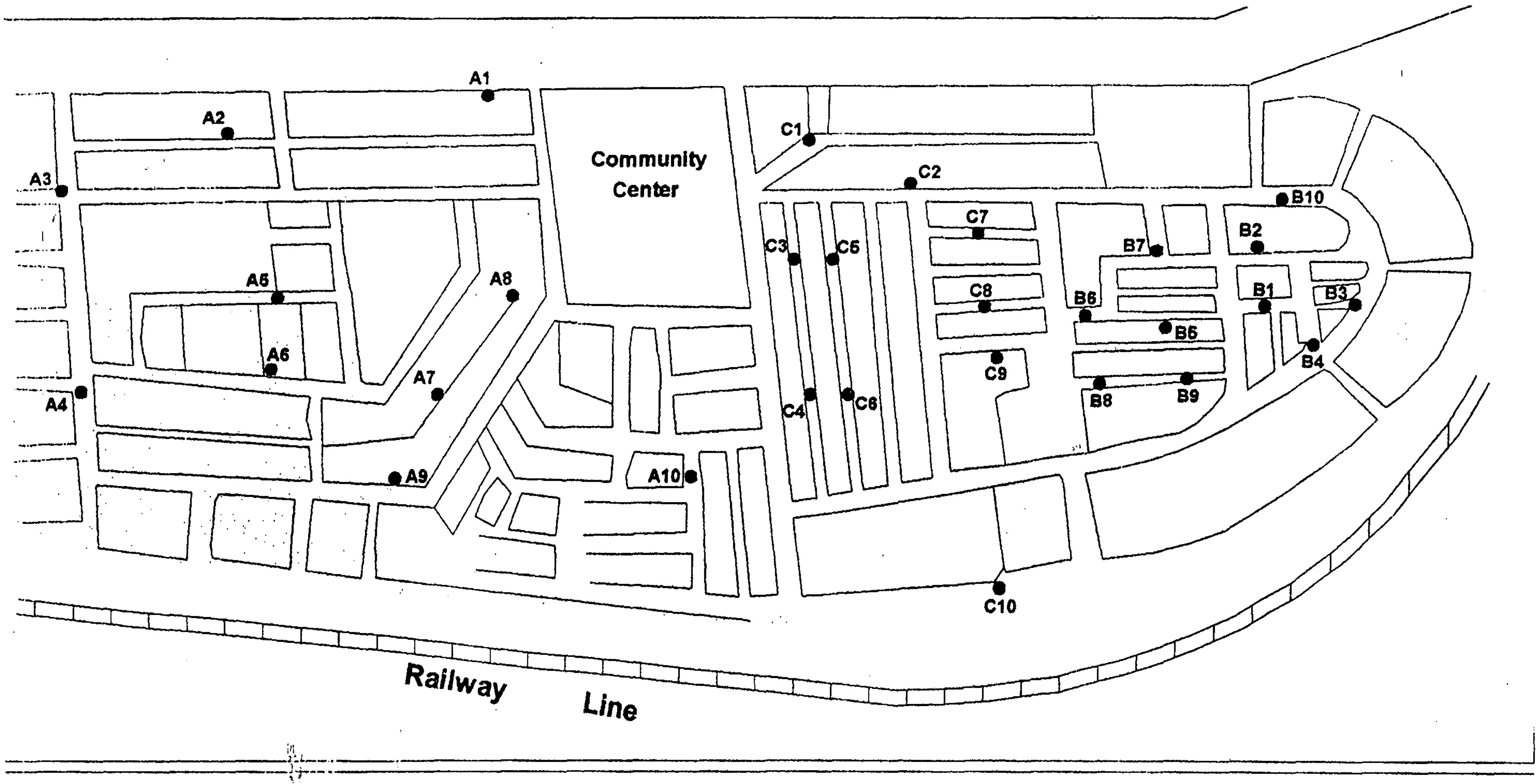
Procedure

1 gram of soil was taken in a 50 ml beaker and was mixed with 2ml of $MgNO_3$ solution and was evaporated to dryness at 70°C. The residue was heated overnight in a stainless steel oven at 300°C. The beaker is cooled and 5cc of HNO_3 (25%) was added, the beaker was covered and digested over water bath for 2 ½ hours. It was then diluted and filtered in a 50ml volumetric flask and the volume was made up.

Suitable amount of the aliquot was taken and 5 cc of acetic acid and 1 ml of H_3PO_4 was added to decolorize any Fe^{3+} ions if present. The aliquot is then subjected for the turbidity determination as according to that of sulfate.



Map3.I Delhi Map Showing Wazirpur Industrial Area and Soil Sampling Sites.



MAP. 3.2. MAP OF WAZIRPUR INDUSTRIAL AREA SHOWING SAMPLING SITES

Plate 1

Plate 2

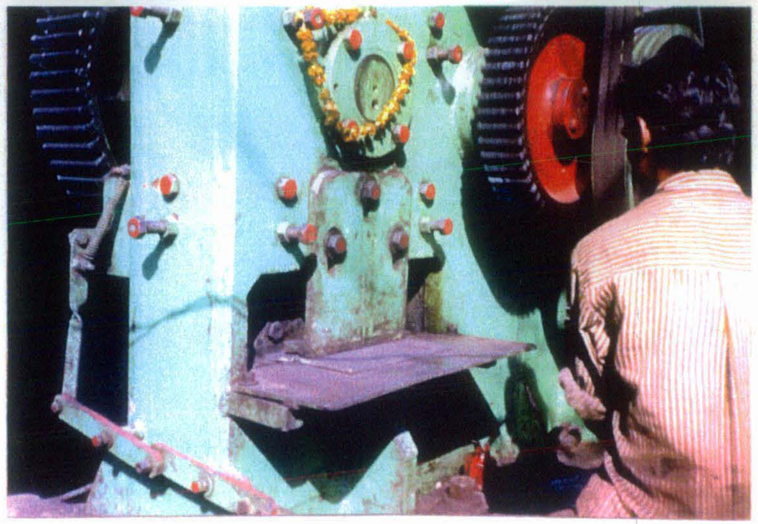


Plate 3

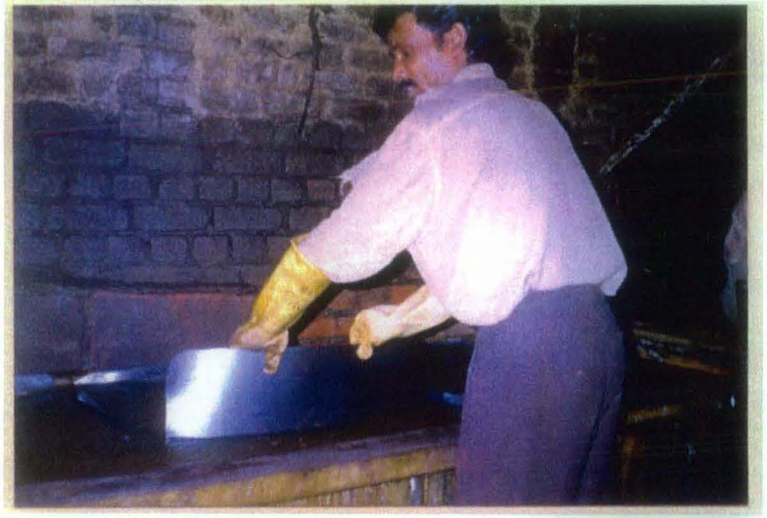


Plate 4

Plate 5

Plate 6

Plate 7

Plate 8

Plate 9

Chapter IV

Results and Discussion

The ultimate aim of the study is to find out the disposal pathway of industrial wastes of Wazirpur area to the land, of which the present study is a part. Before disposing the industrial waste to the soil it should be treated to get rid of pathogens. Then waste should be treated to bring down the toxicity level to the permissible limits. For the disposal of waste, soils have been collected from two different sites that have some basic differences in nature. The present work comprises of finding out the status of Sulfur in the soils when it is treated with the waste generated in Wazirpur Industrial Area.

4.1. Physico-chemical characteristics of pure wastes

The wastes collected from the roadside dumps of Wazirpur Industrial Area are acidic in nature in all the seasons: monsoon, winter and summer. This is because of practice of pickling process (acid washing) in the steel processing industries of this area.

Table 4.1: Physico-chemical characteristics of pure wastes.

	Different types of waste ↓		
Parameters ↓	Monsoon	Summer	Winter
Moist. cont.(%)	2.94	1.98	2.54
WHC (%)	46.63	39.75	49.88
pH	3.1	2.75	2.96
EC(mS/cm) (dS/m)	1.921	1.700	1.100
Org. Carbon (%)	3.974	3.280	3.116
CEC (meq/100g)	11.822	12.211	12.987
Total Sulfur (ppm)	191.417	189.925	219.029
Available Sulfate(ppm)	134.789	125.484	147.008
PO_4^{3-} ext. Sulfate(ppm)	158.745	157.568	189.223

Could be roundup after the marks no decimal.

The physical properties of wastes show that winter waste is highly acidic (pH 2.75) followed by summer waste and then the monsoon waste (Table 4.1). The highest pH of the monsoon waste is attributed to the fact that the acids get washed away due to rains in the monsoon season. This is one of the reasons for high moisture content of the monsoon waste. The organic carbon content and CEC of the three kinds of wastes are almost the same. Winter waste is having the lowest electrical conductivity while EC of monsoon and winter waste are almost of the same range (winter waste has lowest EC i.e. 1.100mS/cm).

Winter waste has the highest Total Sulfur content (219.029ppm) followed by Monsoon waste (191.417ppm). The summer waste has lowest Total Sulfur Content (189.925ppm). Available sulfate (water extractable) was highest in case of winter waste (147.008ppm) followed by monsoon waste (134.789ppm). Summer waste has the least (125.484ppm). Total sulfate (phosphate extractable) was maximum in case of winter waste followed by summer waste (157.568ppm). The Monsoon waste has least value (154.745ppm). The waste contains 7%(Monsoon waste) to 15% (Winter Waste) of iron (total),since most of industries of Wazirpur are involve in iron and steel processing.

4.2. Physico-chemical characteristics of pure soils

The two soils differ in their basic nature. JNU soil is nursery soil without any anthropogenic disturbances while Chhattarpur soil is farmland soil where activities including fertilizers, manures and pesticides are applied to the field to grow vegetables. Chhattarpur soil is situated within 5 km radius of Badarpur Thermal Power Station and fly ash and other pollutant are likely to contaminate these soils. These conditions are responsible for the differences in the few physico-chemical properties of the soils.

The soil samples collected from two different sites differ mainly in % water holding capacity and electrical conductivity. But the difference is not significant regarding Moisture content, EC and CEC (Table 4.2).

The soil of Chhattarpur farmhouse has higher clay content then JNU soil. Where as the JNU soil has higher sand content. The Chattarpur soil contains higher amount of total sulfur (15.642ppm); Available sulfate (0.900ppm) and Total sulfate (1.781ppm) than the JNU soil. The JNU soil has total sulfur 14.847ppm; total sulfate 1.489ppm and available sulfate 0.711ppm. Pure JNU soil has higher iron content (1.1%) than Chhattarpur soil(0.47%).

Table 4.2: Physico-chemical characteristics of pure soils

Parameter	JNU	Chhattarpur
Moist cont (%)	**0.67**	**1.53**
WHC (%)	**39.9**	**44.75**
pH	**8.34**	**8.82**
EC (mS/cm)	**0.115**	**0.199**
Org C (%)	**0.401**	**0.755**
CEC (meq/100g)	**10.777**	**11.867**
Total sulfur(ppm)	**14.847**	**15.642**
Available sulfate(ppm)	**0.711**	**0.9**
PO$_4^{3-}$ extractable Sulfate(ppm)	**1.489**	**1.781**
Sand (%)	**68.0**	**62.8**
Silt (%)	**21.9**	**23.2**
Clay (%)	**10.1**	**14.0**

Too low ?

Data to be re-checked once ?

4.3 pH

pH is the most important and basic physical property of the soils. Almost every process occurring in the soil is governed by the pH of the soil. The mineralization of sulfur as well as the transformation of sulfate from non-available to available form is also pH dependent. It has been observed that with increase in the pH, desorption of the sulfate adsorbed on soil takes place and it becomes readily available to plant (Barrow, 1970; Couth et al, 1979; Bolan el al., 1986; Nodvin et al., 1986). Hence, the study of pH is necessary to understand the physical and chemical changes undergoing in the soil system due to application of the industrial waste.

In the present case the soils under study are alkaline soils (JNU soil 8.34; Chhattarpur soil- 8.82); but the wastes are highly acidic. However, acidic wastes, raise are first treated with lime in different percentage to lower their pH and then applied to the soils. With the incubation there is change in the pH of treated soils that is observed in the Tables 4.3.1(for Chhattarpur Soil) and 4.3.2(for JNU soil). Pure soil showed decreasing trend in pH with incubation. With the application of waste to the soil brings down the pH of soil. However addition of lime lowers down the acidity of the waste–soil mixture, which indicates the addition of Lime has positively neutralized the acidic waste

Chhattarpur soil (Table.4.3.1) is basic in nature (pH 8.82) while solid wastes are highly acidic. When the Chhattarpur soil is mixed with solid wastes in different proportions (i.e. 10%, 20% and 30% of waste), pH occupies a range of 6.9-7.83 in different period of incubation as shown in (Table No. 4.3.1) .The corresponding figure at the end of incubation period are 6.24-7.57. JNU soil (Table 4.3.2) is also alkaline in nature (pH 8.34). When it is mixed with solid wastes (acidic), pH values decrease, ranging between 7.26-7.73at initial stages and the corresponding figure at the end of incubation period is 7.56-7.76. The pH changed with different lime treatments and different days of incubation. When the solid waste was treated with lime and mixed JNU soil, the pH range was between 7.3 and 8.05. The corresponding values for Chhattarpur soil are 6.28-7.83

Chhattarpur soil, when mixed with different proportion of monsoon wastes (10%, 20% and 30%), showed the pH values of 7.76, 7.21 and 6.9 at the initial stage and 7.57, 7.21 and 6.62 at the end of incubation period respectively. JNU soil, when mixed with different proportion of monsoon wastes (10%, 20% and 30%), showed the pH values of 7.34, 7.43 and 7.26 at the initial stage and 7.75, 7.74 and 7.64 at the end of incubation period respectively. By the application of lime there is increase in pH.

Chhattarpur soil, when mixed with different proportion of summer waste (10%, 20% and 30%), indicated that the pH values are 7.83,7.37 and 7.08 respectively at the initial stage of incubation and without any lime treatment. The corresponding values at the end of incubation period of 120 days are7.58,7.27 & 6.98 respectively. The JNU soil, when mixed with different proportion of summer waste (10%, 20% and 30%), indicated that the pH values are 7.6, 7.48 and 7.40 respectively at the initial stage of incubation without any lime treatment. The incubation leads the change of pH values to 7.76, 7.76, and 7.61 the end of period for 10%, 20% and 30% waste amendment respectively.

Chhattarpur soil, when mixed with different proportion of winter waste (10%, 20% and 30%), indicated that the pH values are 7.78, 7.41, 6.96 respectively, at the initial stage of incubation, and 7.51, 7.38, and 6.24 at the end of incubation period (without any lime treatment). JNU soil, when mixed with different proportion of winter waste (10%, 20% and 30%), indicated that the pH values are 7.73, 7.51, and 7.38, respectively at the initial stage of incubation without any lime treatment. The incubation leads the change of pH values to

7.61,7.67, & 7.61 the end of period for 10%, 20% and 30% waste amendment respectively. Similar results were obtained by Kings and Morris 1972.

By the application of lime there is increase in pH. The liming of the soil – waste mixture neutralize the acidity. Besides, when incubation is considered, the buffering capacity of soil plays an important part and the soil tends to resist any change in its pH and it tends towards the neutralizing any the change made. The pH buffering have been correlated with to various properties such as clay content, and organic matter, (Conyenrs 2000).

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SR(?)

In case of controlled JNU soil (Table No. 5.3.2) under incubation the pH of the soil tends to decrease from the initial value (8.34) till 30th day and then an increase is observed (8.34) which again starts decreasing and ultimately attaining almost constant value towards the end of the incubation period (90-120 day). The results are quite different in case of 10% summer waste mixed with JNU soil i.e. pH of JNU soil increased from 7.6 to 7.93 after 45 days of incubation; afterwards it decreased to (pH-7.76) on 120 days of incubation. But, when treated 0.5% limes, pH first increased till 20 days of incubation, after which it got stabilized and pH ranges between 7.79 and 7.81. By the application of 1% lime, pH value decreased up to 45th day, then got stabilized following the same trend. In case of 20% solid waste mixed soil, the pH was observed between 7.48 on 0th day ,7.92 (10th day) and after that it decreased and got stabilized with time. By the application of 0.5% lime in 30% summer waste mixed soil, pH got stabilized after 20 days of incubation.

The ANOVA of the pH variation of JNU soil and Chhattarpur soil was carried out, considering 'percentage of waste,' 'lime treatment,' 'days of Incubation' and 'Replications,' it was observed that in case of Chhattarpur soil the interaction between variables i.e. 'lime treatment' and 'days' as well as 'lime treatment' and 'Percentage of waste' was found to be non-significant. However in case of JNU soil, only the 'waste treatment' and the 'replication of the results were found to be significant. The adjusted R^2 Value was 0.2487 in case of Chattarpur soil and 0.1533 incase of JNU soil.

Table 4.3.1: - Variation of pH of waste amended Chhattarpur soil upon incubation

	Days of incubations							
Samples	**0days**	**10days**	**20days**	**30days**	**45days**	**60days**	**90days**	**120days**
C-0-0	8.82	8.32	8.24	8.94	8.22	8.1	8.03	8.02
CM-10-0	7.76	7.65	7.7	7.67	7.37	6.93	7.7	7.57
CM-10-0.5	7.78	7.64	7.71	7.89	7.42	7.69	7.71	7.71
CM-10-1.0	7.93	7.74	7.75	8.11	7.44	7.71	7.38	7.19
CM-20-0	7.21	7.37	7.34	6.69	7.16	7.35	7.41	7.21
CM-20-.5	7.36	7.43	7.46	7..39	7.13	7.44	7.44	7.37
CM-20-1.0	7.57	7.52	7.53	7.67	7.29	7.48	7.52	7.4
CM-30-0	6.9	7.09	7.34	5.01	6.6	6.67	6.2	6.62
CM-30-0.5	7.1	7.58	7.18	7.26	7	7.11	7.15	7.02
CM-30-1.0	7.39	7.37	7.37	7.46	7.28	7.36	7.48	7.29
CS-10-0	7.83	7.63	7.67	6.84	7.52	7.69	7.73	7.58
CS-10-0.5	7.82	7.62	7.7	6.95	7.46	7.63	7.73	7.58
CS-101.0	8.1	7.77	7.76	7.41	7.55	7.67	7.78	7.58
CS-20-0	7.37	7.29	7.41	6.20	7.04	7.35	7.42	7.27
CS-20-0.5	7.54	7.36	7.49	6.65	7.33	7.48	7.53	7.38
CS-20-1.0	7.83	7.43	7.61	7.09	7.55	7.6	7.59	7.51
CS-30-0	7.08	6.86	7.18	6.61	6.47	6.99	6.97	6.98
CS-30-0.5	7.3	7.3	7.05	6.30	6.96	7.26	7.28	7.17
CS-30-1.0	7.66	7.36	7.43	6.63	7.16	7.44	7.55	7.39
CW10-0	7.78	7.58	7.67	7.60	7.56	7.44	7.65	7.51
CW-10-0.5	7.82	7.69	7.77	7.93	7.58	7.7	7.72	7.57
CW-10-1.0	7.59	7.7	7.33	8.11	7.62	7.72	7.32	7.24
CW-20-0.0	7.41	7.27	7.45	7.15	7.22	7.33	7.52	7.38
CW-20-0.5	7.52	7.37	7.52	7.56	7.32	7.44	7.48	7.42
CW-20-1.0	7.22	7.48	6.88	7.95	7.39	7.55	7.59	6.91
CW-30-0.0	6.96	6.96	7.22	6.41	6.84	6.62	7.32	6.24
CW-30-0.5	7.17	7.18	7.37	7.27	6.95	7.03	7.09	7.02
CW-30-1.0	7.5	7.06	7.16	7.52	7.14	7.29	7.29	7.57

Abbreviation :- (All the values are mean of three replicas)

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-Winter waste;
S-Summer waste .

Notation e.g.
CW^1 -10^2- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste;
3- percentage of lime treatment ;

Table 4.3.2: - Variation of pH of JNU soil upon incubation

	Days of Incubation							
Samples	**0days**	**10days**	**20days**	**30days**	**45days**	**60days**	**90days**	**120days**
J-0-0	8.34	8.3	8.21	8.11	8.16	8.19	8.14	8.11
JM-10-0	7.34	7.76	7.7	7.66	7.76	7.76	7.78	7.75
JM-10-0.5	7.56	7.78	7.73	7.74	7.83	7.69	7.74	7.76
JM-10-1.0	7.36	7.73	7.74	7.76	7.77	7.7	7.68	7.79
JM-20-0	7.43	7.6	7.57	7.49	7.74	7.71	7.76	7.74
JNM-20-.5	7.58	7.57	7.58	7.53	7.68	7.58	7.58	7.63
JM-20-1.0	7.3	7.66	7.6	7.58	7.72	7.58	7.62	7.65
JM-30-0	7.26	7.43	7.39	7.44	7.59	7.64	7.63	7.64
JM-30--0.5	7.58	7.45	7.47	7.51	7.57	7.6	7.58	7.6
JM-30-1.0	7.67	7.55	7.56	7.55	7.66	7.86	7.53	7.7
JS-10-0	7.6	7.72	7.74	7.47	7.93	7.89	7.78	7.76
JS-10-0.5	7.72	7.8	7.94	7.81	7.79	7.86	7.79	7.77
JS-101.0	7.96	7.83	7.78	7.78	7.68	7.85	7.66	7.78
JS-20-0	7.48	7.92	7.57	7.6	7.66	7.61	7.7	7.76
JS-20-0.5	7.64	7.67	7.63	7.53	7.76	7.65	7.67	7.69
JS-20-1.0	7.96	7.7	7.74	7.54	7.57	7.68	7.57	7.58
JS-30-0	7.4	7.94	7.49	7.55	7.58	7.63	7.56	7.61
JS-30-0.5	7.5	7.51	7.52	7.54	7.4	7.57	7.49	7.49
JS-30-1.0	8.05	7.9	7.71	7.63	7.6	7.57	7.59	7.5
JW10-0	7.73	7.81	7.76	7.66	7.87	7.87	7.78	7.61
JW-10-0.5	7.72	7.79	7.79	7.69	7.92	7.84	7.75	7.73
JW-10-1.0	7.79	7.86	7.75	7.73	7.96	7.7	7.81	7.76
JW-20-0.0	7.51	7.66	7.64	7.48	7.72	7.7	7.6	7.67
JW-20-0.5	7.56	7.72	7.74	7.56	7.68	7.66	7.65	7.68
JW-20-1.0	7.84	7.78	7.58	7.61	7.7	7.54	7.69	7.73
JW-30-0.5	7.38	7.49	7.63	7.51	7.64	7.56	7.56	7.61
JW-30-0.0	7.45	7.47	7.56	7.46	7.64	7.25	7.53	7.56
JW-30-1.0	7.73	7.61	7.6	7.52	7.6	7.56	7.79	7.66

(All the values are mean of three replicas)

Abbreviation

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste; S-Summer waste .

Notation e.g. JW[1] -10[2]- 0.5%[3] :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

4.4 ELECTRICAL CONDUCTIVITY (EC)

EC denotes the amount of ions present in free form in the soil solution that can pass electricity. The more ions present, the higher the electrical conductivity of the particular soil solution. It is the basic physical property of the soils and characteristic of physical and chemical condition of the soil solution.(Brady 2000). Value of EC in different samples (both Chhattarpur and JNU soil, mixed with solid wastes) is below 2 mS/cm. In pure Chhattarpur soil (table no 4.4.1), the EC ranges from 0.199 mS/cm to 0.106 mS/cm in different days of incubation. In pure JNU soil, (table no4.4.2) EC was found in the change from 0.115 to 0.106 mS/cm . With addition of waste the EC of the mixture increased.

Chhattarpur soil, when mixed with different proportion of monsoon wastes (10%, 20% and 30%), showed the EC values of 0.831 mS/Cm , 1.313 mS /cm and 1.693 mS /cm at 0 th day of incubation and 0.518 mS /cm, 0.681 mS /cm and 0.806 mS /cm at the end of 120 days.Similarly corresponding values for Monsoon waste amended JNU soil are 0.563 mS/cm, 0.5 mS/cm and 1.080 mS/cm at the initial stage and 0.404 mS/cm ,0.646 mS/cm and 0.676 mS/cm. at the end of incubation period respectively. By the application of lime there is increase in EC.

Chhattarpur soil, when mixed with different proportion of summer waste (10%, 20% and 30%), indicated that the EC values are 0.579 mS/Cm, 1.004 mS/Cm and 1.011 mS /cm respectively at the initial stage of incubation without any lime treatment. The incubation lead to change of EC value to and 0.368 mS/Cm ,0.647 mS /cm and 0.913 mS /cm mS /cm at the end of 120 days of incubation. Similarly corresponding values of EC for Summer waste amended Chhattarpur soil are 0.315 mS/cm, 0.492 mS/cm and 0.644 mS/cm at 0th day of incubation and 0.271 mS/cm, 0.540 mS/cm and 0.691 mS/cm the end of period for 10% , 20% and 30% waste amendment respectively.

Similar trends were observed in case of winter waste amended JNU soil, when mixed with different proportion of winter waste (10%, 20% and 30%), indicated that the EC values are 0.543 mS/cm, 0.377 mS/cm and 0.535 mS/cm respectively at the initial stage of incubation without any lime treatment. The incubation leads to change of EC value to 0.453 mS/cm 0.308 mS/cm and 0.402 mS/cm respectively at the end of period for 10% , 20% and 30% waste amendment respectively. The corresponding values of EC for winter waste amended Chhattarpur soil are 0.835 mS/Cm, 1.111 mS/Cm and 1.148 mS /cm at 0 th day of incubation and 0.807 mS/Cm ,0715 mS /cm and 0.763 mS /cm at the end of 120 days. Similar results have been observed by Tiwari(1996), by amending irrigational land with treated wastewater .

The ANOVA of the EC variation of JNU soil and Chhattarpur soil was carried out , considering percentage of waste, lime treatment , days of Incubation and Replications, it was observed that variable 'Waste' and 'Lime treatment' as well as their interaction is found to be significant. The adjusted R^2 Value was 0.0020 in case of Chattarpur soil and 0.0010 incase of JNU soil.

Table 4.4.1:- variation of EC of waste amended Chhattarpur Soil with incubation

	Days of incubations							
	0 days	**10 days**	**20 days**	**30 days**	**45 days**	**60 days**	**90 days**	**120 days**
C-0-0	0.115	0.120	0.152	0.192	0.125	0.107	0.096	0.106
CM-10-0	0.563	0.388	0.497	0.860	0.519	0.404	1.049	0.404
CM-10-0.5	0.534	0.403	0.512	0.777	0.384	0.401	1.044	0.394
CM-10-1.0	0.555	0.386	0.505	0.744	0.452	0.646	0.761	0.412
CM-20-0	0.834	0.621	0.731	1.029	0.641	0.643	0.852	0.646
CM-20-0.5	0.819	0.702	0.755	0.840	0.667	0.673	0.663	0.611
CM-20-I.0	0.846	0.608	0.785	1.281	0.905	0.795	0.868	0.586
CM-30-0	1.080	0.810	0.663	0.967	0.519	0.430	0.703	0.676
CM-30-0.5	1.063	0.492	0.657	1.004	0.366	0.418	0.693	0.683
CM-30-1.0	1.104	0.826	0.666	1.167	0.416	0.399	0.786	0.997
CS-10-0	0.315	0.375	0.472	0.627	0.335	0.319	0.316	0.271
CS-10-0.5	0.370	0.498	0.419	0.674	0.363	0.370	0.445	0.396
CS-101.0	0.335	0.488	0.604	0.651	0.346	0.334	0.371	0.372
CS-20-0	0.492	0.757	0.716	0.941	0.532	0.506	0.781	0.540
CS-20-0.5	0.533	0.798	0.698	0.928	0.584	0.514	0.744	0.542
CS-20-1.0	0.570	0.792	0.722	0.923	0.522	0.507	0.782	0.532
CS-30-0	0.644	0.890	0.925	1.015	1.025	0.678	1.080	0.691
CS-30-0.5	0.624	0.988	1.001	1.120	0.698	0.588	0.987	0.620
CS-30-1.0	0.649	1.016	0.889	1.129	0.681	0.550	0.095	0.610
CW-10-0	0.543	0.742	0.702	0.503	0.436	0.431	0.548	0.453
CW-10-0.5	0.296	0.485	0.446	0.538	0.190	0.199	0.403	0.254
CW-101.0	0.346	0.896	0.511	0.457	0.261	0.264	0.414	0.299
CW-20-0	0.377	0.789	0.732	0.690	0.370	0.452	0.577	0.308
CW-20-0.5	0.487	0.827	0.768	0.697	0.461	0.441	0.623	0.487
CW-20-1.0	0.500	0.887	0.799	0.727	0.500	0.488	0.699	0.500
CW-30-0	0.535	0.986	0.913	0.825	0.581	0.564	0.953	0.402
CW-30-0.5	0.634	0.999	0.957	0.806	0.605	0.648	0.933	0.453
CW-30-1.0	0.654	1.144	1.027	0.842	0.655	0.691	0.898	0.477

(All the values are mean of three replicas)

Abbreviation W

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste;
S-Summer waste .

Notation e.g.

CW[1] -10[2]- 0.5%[3] :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

Table 4.4.2:- variation of EC of waste amended Chattarpur Soil with incubation

	Days of incubation							
	0 days	10 days	20 days	30 days	45 days	60 days	90 days	120 days
J-0-0	0.199	0.239	0.283	0.313	0.294	0.329	0.349	0.357
JM-10-0	0.831	0.834	0.843	0.855	0.697	0.633	0.698	0.518
JM-10-0.5	0.841	0.799	0.737	1.008	0.621	0.49	0.662	0.55
JM-101.0	0.847	0.798	0.703	0.912	0.577	0.484	1.032	0.594
JM-20-0	1.313	1.307	1.331	1.726	0.825	0.75	1.01	0.681
JM-20-0.5	1.313	1.268	1.278	1.583	0.831	0.802	1.016	0.700
JM-20-1.0	1.314	1.325	1.336	1.360	0.782	0.751	1.114	0.475
JM-30-0	1.693	1.679	1.586	1.354	1.050	0.947	1.260	0.806
JM-30-0.5	1.7	1.693	1.599	1.426	1.038	0.892	1.359	0.759
JM-30-1.0	1.704	1.715	1.644	1.849	0.992	0.977	0.965	0.915
JS-10-0	0.579	0.673	0.702	0.799	0.483	0.368	1.013	0.368
JS-10-0.5	0.645	0.768	0.801	0.803	0.588	0.424	1.067	0.417
JS-10-1.0	0.622	0.727	0.763	0.733	0.451	0.645	0.760	0.411
JS-20-0	1.004	1.088	1.112	1.037	0.642	0.644	0.853	0.647
JS-20-.5	1.091	1.116	1.139	0.844	0.678	0.684	0.674	0.622
JS-20-I.0	1.109	1.858	1.207	1.296	0.928	0.818	0.891	0.609
JS-30-0	1.011	1.508	1.208	1.090	0.945	0.855	1.253	0.913
JS-30--0.5	0.997	1.583	1.092	1.051	0.93	0.886	1.077	0.868
JS-30-1.0	1.043	1.590	1.594	1.631	0.948	0.875	1.478	0.872
JW-10-0	0.835	0.824	0.853	1.172	0.650	0.561	0.834	0.807
JW-10-0.5	0.634	0.598	0.630	0.904	0.299	0.351	0.626	0.616
JW-10-1.0	0.72	0.883	0.709	1.189	0.433	0.416	0.803	1.014
JW-20-0	1.111	1.040	1.053	0.919	0.765	0.687	0.946	0.715
JW-20-.5	1.141	1.007	1.021	0.112	0.760	0.620	0.986	0.593
JW-20-I.0	1.543	1.041	1.056	1.252	0.741	0.658	1.207	0.660
JW-30-0	1.486	1.260	1.197	1.556	0.885	0.820	1.230	0.763
JW-30--0.5	1.596	1.370	1.277	1.374	0.954	0.800	1.385	0.796
JW-30-1.0	1.671	1.465	1.372	1.335	0.951	0.461	1.541	0.894

(All the values are mean of three replicas)

Abbreviation

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste; S-Summer waste.

Notation e.g.

JW^1 -10^2- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

4.5 ORGANIC CARBON

Carbon is the chief element present in soil organic matter, comprising 48% to 58% of the total weight. Therefore organic carbon determination is often used as the basis for organic matter estimation (through multiplying the organic carbon value by a factor). Van Bemmelen Factor of 1.724 is used, based on the assumption that the organic matter contains 58% organic carbon.

The organic content of the soil is only 5% by volume influencing the soil properties and plant growth. It is a major source of phosphorous and sulfur and sole source of nitrogen in soil. Finally the organic matter is the main source of energy for soil microorganisms. In the formation of the fertile soil, organic substance plays a diverse role, as they are the source of plant nutrients, which are released in available forms during mineralization. Humus can be considered to be a storehouse of various nutrients essential for the plant growth. In a study of four different soils by Ronse et al (1988) organic matter contents have increased, generally more in the upper layers than in the sub soils.

Is it missing?

The organic matter is an important factor associated with the availability of sulfur. It has been observed that various organic ligand compete with sulfur for adsorption on soil (Krug and Frink, 1983; Johnson et al., 1980; Fuller et al., 1985). As the organic matter is the main source of energy for soil microorganisms. In the formation of the fertile soil organic substance play a diverse role, as they are the source of plant nutrients, which are released in available forms during mineralization. Humus can be considered to be a store home of various nutrients essential for the plant growth.

Is it only Johnson?

house

Among the solid wastes the organic carbon is highest in the monsoon waste(3.974%) followed by winter(3.280%) and summer waste (3.116%) (Table 4..1). Among the soil the Chhattarpur soil (0.755%) has higher percentage of organic carbon than JNU soil (0.401%)

Chhattarpur soil, (Table 4.5.2) when mixed with different proportion of monsoon wastes (10%, 20% and 30%), the organic carbon percentage values were0.868%, 1.006% and 1.552% at the initial stage and 0.683% 0.847%, 0.990% at the end of incubation period respectively. The corresponding values of organic carbon for Monsoon waste amended JNU soil (Table 4.5.1) are 0.440 %, 0.621% and 0.893% at 0^{m} day of incubation and 0.370% , 0.554% and 0.557%.at the end of 120 days.

Chhattarpur soil, when mixed with different proportion of summer waste (10%, 20% and 30%), indicated that the organic carbon values are 0.833%, 1.079 % and 1.227 % respectively at the initial stage of incubation without any lime treatment. The incubation decrease the value of organic carbon value to 0.641 % 0.835 %, and 0.946 % at the end of period for 10%, 20% and 30% waste amendment respectively. The corresponding values of organic carbon for Summer waste amended JNU soil are 0.745%, 0.957%, and 1.153% initially and 0.557% 0.887% and 1.020% at the end of 120 days.

Similar trends were observed in case of winter waste amended Chhattarpur Soil, when mixed with different proportion of winter waste (10%, 20% and 30%), indicated that the organic carbon values are 0924%, 0.936% and 1.136% respectively at the initial stage of incubation without any lime treatment. The incubation leads to change of organic carbon value to 0.784 %, 0.714% and 0.905% respectively at the end of period of 120 days for 10%, 20% and 30% waste amendment respectively. For winter waste amended JNU soil the corresponding values of organic carbon are 0.608%, 0.679% and 0.787% at 0th day of incubation and 0.615%, 0.535% and 0.652% at the end of incubation period i.e. 120 days

Thus in both case, when JNU and Chhattarpur soil separately mixed with different percentage of solid waste, there has been a significant increase in organic carbon with respect to the amount of waste added. However, from the experimental results it was concluded that lime treatment makes no significant difference in value of organic carbon of a given soil-waste mixture. Increase in organic carbon was obtained by Tiwari et al (1996) when the soils were irrigated by sewage water.

The waste soil mixture upon incubation showed decrease in the value of organic carbon with time. A steady decrease was observed in case of Chhattarpur soil (un amended) whereas in case of JNU soil there has been a continuous decrease observed till 30th day followed by an increase at 45th day, which ultimately attains nearly constant value. When the un-amended soil are considered it has been observed that in case of Chhattarpur soil a decrease has been noticed till 45 days and then value after wards get stabilized whereas in case of JNU soil the organic carbon decreases till30days . At 45 days an increase from the previous value has been observed. Which then decreases and attains a stable value. Maximum decrease has been observed in case of 1.0 % lime treated and 30% monsoon waste amended Chhattarpur soil .i.e. 37% (from 0.941to 0.841%) observed in case of 0.5%lime treated 20 % monsoon waste amended JNU soil by 36% (from 0.647 to 0.413%) after the end of incubation period. Minimum decrease has been observed in case of 0.5% lime treated and 20% monsoon waste treated Chhattarpur soil.i.e.11.05%(from 0.950 to 0.841%) as well as in case of 1.0 % lime treated 30 % winter waste amended JNU soil by 2.5% (from 0.831 to 0.810 %) after the end of incubation period

The ANOVA of the variation of organic Carbon of JNU soil and Chhattarpur soil was carried out , considering 'percentage of waste', 'lime treatment' , 'days of Incubation' and 'Replications', it was observed that in both cases (Chhattarpur soil as well as JNU soil) the interaction between two variables i.e. 'lime treatment' and 'days of incubations' was found to be non-significant.. The adjusted R^2 Value was 0.7543 in case of Chattarpur soil and 0.8069 incase of JNU soil.

Table 4.5.1: Variation of value of organic Carbon (in %) of waste amende Chhattarpur soil with days of incubation

	Days of incubation							
	0 days	**10 days**	**20 days**	**30 days**	**45 days**	**60 days**	**90 days**	**120 days**
C-0-0	0.755	0.755	0.662	0.631	0.49	0.490	0.454	0.388
CM-10-0	0.868	0.785	0.725	0.692	0.694	0.686	0.675	0.683
CM-10-0.5	0.897	0.717	0.787	0.753	0.782	0.728	0.719	0.726
CM-10-1.0	0.939	0.817	0.830	0.79	0.762	0.756	0.741	0.776
CM-20-0	1.006	0.931	0.982	0.854	0.819	0.818	0.814	0.847
CM-20-0.5	0.950	0.932	0.884	0.851	0.812	0.825	0.822	0.841
CM-20-1.0	1.061	0.977	0.993	0.959	0.883	0.875	0.856	0.846
CM-30-0	1.552	1.349	1.109	1.053	0.986	0.977	0.993	0.990
CM-30-0.5	1.532	1.391	1.287	1.210	1.008	0.991	0.992	0.992
CM-30-1.0	1.501	1.405	1.039	1.038	0.967	0.937	0.935	0.933
CS-10-0	0.833	0.735	0.697	0.660	0.656	0.668	0.617	0.641
CS-10-0.5	0.991	0.908	0.901	0.802	0.759	0.751	0.702	0.690
CS-101.0	0.881	0.783	0.783	0.718	0.634	0.643	0.659	0.653
CS-20-0	1.079	0.860	0.806	0.8	0.789	0.808	0.806	0.835
CS-20-0.5	1.077	0.888	0.801	0.818	0.822	0.797	0.753	0.772
CS-20-1.0	1.045	1.016	0.979	0.896	0.837	0.829	0.809	0.787
CS-30-0	1.227	0.919	1.026	0.93	0.949	0.949	0.936	0.946
CS-30-0.5	1.159	0.9	0.996	0.912	0.911	0.918	0.914	0.924
CS-30-1.0	1.226	1.006	1.005	0.973	0.920	0.922	0.923	0.932
CW-10-0	0.924	0.848	0.850	0.935	0.787	0.800	0.769	0.784
CW-10-0.5	0.749	0.724	0.639	0.574	0.601	0.619	0.602	0.636
CW-101.0	0.817	0.774	0.752	0.777	0.702	0.709	0.647	0.666
CW-20-0	0.936	0.794	0.853	0.811	0.756	0.708	0.698	0.714
CW-20-0.5	0.918	0.771	0.809	0.78	0.734	0.727	0.712	0.716
CW-20-1.0	0.901	0.801	0.895	0.844	0.795	0.739	0.773	0.752
CW-30-0	1.136	1.037	1.047	1.048	0.930	0.935	0.894	0.905
CW-30-0.5	1.169	1.073	1.067	1.072	1.028	0.980	0.931	0.911
CW-30-1.0	1.178	1.171	1.164	1.201	0.948	0.961	0.947	0.958

(All the values are mean of three replicas)

Abbreviation C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste;

S-Summer waste .

Notation e.g.

CW^1 -10^2- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

Table 4.5.2: Variation of organic Carbon of waste amended JNU soil with incubation

	Days of incubations							
	0 days	**10 days**	**20 days**	**30 days**	**45 days**	**60 days**	**90 days**	**120 days**
J-0-0	0.401	0.318	0.331	0.326	0.409	0.349	0.373	0.324
JM-10-0	0.440	0.461	0.476	0.499	0.508	0.523	0.543	0.470
JM-10-0.5	0.536	0.395	0.371	0.537	0.544	0.476	0.467	0.375
JM-101.0	0.563	0.472	0.465	0.563	0.588	0.502	0.593	0.472
JM-20-0	0.621	0.595	0.588	0.624	0.656	0.592	0.666	0.554
JM-20-0.5	0.647	0.406	0.410	0.533	0.589	0.484	0.662	0.413
JM-20-1.0	0.680	0.587	0.506	0.547	0.584	0.554	0.609	0.538
JM-30-0	0.793	0.519	0.527	0.524	0.595	0.594	0.605	0.557
JM-30-0.5	0.858	0.791	0.745	0.864	0.861	0.725	0.791	0.736
JM-30-1.0	0.897	0.902	0.910	0.829	0.899	0.819	1.009	0.907
JS-10-0	0.745	0.538	0.572	0.719	0.742	0.548	0.753	0.557
JS-10-0.5	0.631	0.618	0.591	0.619	0.595	0.567	0.602	0.576
JS-10-1.0	0.666	0.620	0.586	0.611	0.695	0.640	0.769	0.531
JS-20-0	0.957	0.897	0.830	1.053	1.004	0.947	0.924	0.887
JS-20-.5	0.799	0.704	0.684	0.755	0.811	0.685	0.691	0.660
JS-20-I.0	0.811	0.722	0.702	0.889	0.928	0.792	1.038	0.688
JS-30-0	1.153	1.165	1.071	1.112	1.037	1.001	1.047	1.020
JS-30—0.5	1.149	1.097	1.084	1.036	1.289	0.988	1.009	1.054
JS-30-1.0	1.020	0.794	0.810	0.984	1.238	0.801	0.843	0.816
JW-10-0	0.608	0.627	0.612	0.538	0.678	0.605	0.588	0.515
JW-10-0.5	0.587	0.465	0.460	0.546	0.522	0.473	0.493	0.464
JW-10-1.0	0.600	0.438	0.427	0.513	0.556	0.520	0.579	0.443
JW-20-0	0.679	0.512	0.509	0.669	0.677	0.491	0.658	0.535
JW-20-.5	0.666	0.577	0.574	0.650	0.614	0.527	0.688	0.579
JW-20-I.0	0.613	0.546	0.548	0.620	0.605	0.581	0.715	0.554
JW-30-0	0.787	0.744	0.661	0.797	0.802	0.706	0.912	0.652
JW-30--0.5	0.789	0.756	0.693	0.806	0.844	0.719	0.870	0.721
JW-30-1.0	0.831	0.781	0.817	0.780	0.841	0.776	0.951	0.810

(all the value are mean of three replicas)

Abbreviation

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste;
S-Summer waste .

Notation e.g.

JW^1 -10^2- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste;
3- percentage of lime treatment ;

4.6 Cation-Exchange Capacity (CEC)

A soil leached with a salt solution has the power to absorb the cations of the percolating solution and to liberate an equivalent amount of others cations. Thus a soil leached with ammonium acetate solution will absorb some ammonium ions and liberate calcium, magnesium and other ions, which will appeared in the leached (Hesse, 1972). The predominant cations involved in exchange are hydrogen, calcium, magnesium, potassium, sodium and ammonium. The exchangeable form is the most important source of immediately available plant nutrient. In general, available cations can be considered as exchangeable cations. The exchangeable cations are generally available to both higher plants and microorganisms. By cations exchange, hydrogen ions from the root hairs and microorganisms replace nutrients cations from the exchangeable complex (Brady, 2000).

The total amount of exchangeable cations that can be hold by a soil is known its cation exchange capacity. No significant correlation was found between the evolution of hydrogen ion concentration and the CEC (Ronse et al, 1988).

The determination of CEC and individual exchangeable cations not only help to evaluate the fertility of soil but also to classify it. Cation exchange capacity is defined as the degree to which a soil can absorb and exchange cations. CEC is highly dependent upon soil texture and organic matter content. In general, more the organic matter and clay with moisture in the soil, higher the CEC. CEC mostly increases with an increase in pH of soil.

Soil organic matter is one of the most important CEC contributors in soil systems. Carboxyl and phenolic hydroxyl matter (Posner 1966; Van Dijk 1971; Hayes and Swift 1978). The contribution of organic matter to CEC of soil has been well recognized. Its average contribution to the CEC of A horizons ranges from 14 to 56% (Thompson et al 1989). Increase in the CEC is influenced by the humification, which the organic matter undergoes when it is incorporated into the soil (Cegarra et al 1983) or in its composting process (Roig et al 1988; Lax et al 1987). The adsorption of sulfur to soil causes alteration in the cation exchange capacity of soil. Sulfate deposition can therefore enhance the leaching of cations, both acid (H^+ and Al^{3+}) and base cations e.g. Ca, Mg, K, & Na (Cronan et al 1978, Johnson and Cole, 1980, Singh et al, 1980, Foster et al 1989, David et al 1991a)

The CEC of the soil waste mixture is dependent upon the nature of the soil aswell as the quantity of waste added In Chhattarpur soil (Table 4.6.1) the CEC is 11.867 meq/100gms and in case of JNU soil, (table no4.6.2) CEC was found to be 10.777 meq/100gms.When the untreated soil are subjected to incubation of 120 days, the CEC decreases to 9.102 meq/100gms (by 23%) for chattarpur soil and to 9.127 meq/100gms(by 15%) after the end of incubation period.

With addition of 10% waste decreases the CEC of the soil. However with increase in the percentage of waste the CEC is also increased, i.e. 30% waste soil mixture has highest value of CEC followed by 20% and then 10 % waste soil mixture.

Chhattarpur soil, when mixed with different proportion of monsoon wastes (10%, 20% and 30%), showed the CEC values 10.258 meq/100gms, 11.551 meq/100gms, and 10.673 meq/100gms at the initial stage (0th day) and 9.060 meq/100gms, 9.898 meq/100gms and 9.844 meq/100gms at the end of incubation period, respectively. By the application of lime there is increase in CEC. Similarly corresponding values for Monsoon waste amended JNU are8.872 meq/100gms, 9.563 meq/100gms, & 12.935 meq/100gms at 0th day of incubation and 11.179 meq/100gms, 11.453 meq/100gms, 11.223 meq/100gms at the end of 120 days.

Chhattarpur soil, when mixed with different proportion of summer waste (10%, 20% and 30%), indicated that the CEC values are 12.088 meq/100gms, 13.138 meq/100gms, & 14.41 meq/100gms *at* the initial stage of incubation without any lime treatment. The incubation lead to change of CEC value to9.844 meq/100gms11.57 meq/100gms and 9.32 meq/100gms at end of period for 10%, 20% and 30% waste amendment respectively. Similarly corresponding values of CEC for Summer waste amended JNU soil 9.171 meq/100gms, 10.731 meq/100gms & 9.474 meq/100gms at the initial stage (0th day of incubation and at the end of 120 days the value are 10.327 meq/100gms, 9.526 meq/100gms, and 10.216 meq/100gm for 10%, 20 and 30 % waste amendment respectively.

Similar trends were observed in case of winter waste amended JNU soil. When mixed with different proportion of winter waste (10%, 20% and 30%), indicated that the CEC values are 10.581 meq/100gms, 10.446 meq/100gms and 13.088 meq/100gms respectively at the initial stage of incubation without any lime treatment are respectively. The incubation leads to change of CEC value to respectively 8.101 meq/100gms , 10.541 meq/100gms and 10.179 meq/100gms at the end of period for 10%, 20% and 30% waste amendment respectively. The corresponding values of CEC for winter waste amended Chhattarpur soil are 11.948 meq/100gms, 12.405 meq/100gms, and 13.320 meq/100gms at 0^{th} day of incubation and 11.745 meq/100gms, 11.791 meq/100gms and 11.87 meq/100gms at the end of 120 days respectively. Similar results were obtained in by Curling (1995) and Bauer David K (1999).

The ANOVA of the CEC variation of JNU soil and Chhattarpur soil was carried out, considering percentage of 'waste', 'lime treatment,' 'days of Incubation' and 'Replications'. The replication were ~~not~~ found to be non significant for both type of soil. The adjusted R^2 Value was 0.7972 in case of Chattarpur soil and 0.8531 incase of JNU soil.

Table 4.6.1 Variation of CEC of waste amended Chhattarpur soil upon incubation

	Days of incubations							
	0 days	**10 days**	**20 days**	**30 days**	**45 days**	**60 days**	**90 days**	**120 days**
C-0-0	11.867	10.441	9.254	10.923	11.153	9.099	8.997	9.102
CM-10-0	10.258	13.393	12.675	14.083	10.904	9.0867	9.0807	9.0597
CM-10-0.5	10.017	11.478	11.856	13.872	10.846	9.88	9.582	9.381
CM-10-1.0	10.016	11.477	12.309	13.871	11.078	10.173	9.8853	9.5513
CM-20-0	11.551	10.612	11.718	15.683	11.095	10.787	10.106	9.898
CM-20-0.5	12.745	10.6	11.706	13.011	11.565	10.977	10.003	9.9397
CM-20-1.0	10.411	12.623	12.012	14.54	10.193	9.824	9.176	8.891
CM-30-0	10.673	11.67	13.028	12.65	11.913	11.127	10.529	9.9923
CM-30-0.5	11.387	11.664	13.265	12.884	14.337	12.371	11.608	11.192
CM-30-1.0	9.967	10.23	10.367	11.185	7.612	8.019	7.973	8.063
CS-10-0	12.088	12.352	11.41	11.874	11.151	10.151	9.955	9.844
CS-10-0.5	12.623	13.363	13.373	13.629	12.171	11.39	10.256	10.096
CS-101.0	10.7	12.385	12.878	14.044	10.7	11.916	10.716	10.207
CS-20-0	13.138	12.181	11.744	12.202	13.881	12.377	11.884	11.57
CS-20-0.5	13.614	12.418	12.699	14.137	14.357	13.126	11.705	11.299
CS-20-1.0	12.665	12.186	12.945	15.346	14.604	12.543	11.032	10.823
CS-30-0	14.41	13.427	12.77	12.064	12.033	4.29	10.02	9.32
CS-30-0.5	15.344	14.376	14.185	13.226	13.928	11.731	10.131	9.681
CS-30-1.0	13.903	14.372	14.397	13.941	13.659	13.824	11.953	10.253
CW-10-0	10.581	10.369	10.606	13.536	8.9413	8.3083	8.0623	8.1013
CW-10-0.5	10.616	10.166	10.398	13.707	9.9277	9.1647	9.0347	8.9407
CW-101.0	10.484	9.794	11.702	11.477	13.372	11.612	10.342	10.162
CW-20-0	10.446	10.233	12.832	13.089	10.446	11.208	10.904	10.541
CW-20-0.5	10.71	10.973	13.359	13.604	15.267	12.934	12.159	11.975
CW-20-1.0	13.363	12.192	11.942	11.947	13.627	11.782	11.231	10.971
CW-30-0	13.088	13.088	12.62	13.842	13.088	11.284	10.72	10.169
CW-30-0.5	13.81	12.639	12.643	12.875	11.922	10.822	10.296	10.114
CW-30-1.0	13.875	12.704	12.708	12.973	11.987	10.887	10.361	10.179

(All the values are mean of three replicas)

Abbreviation

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste: S-Summer waste .

Notation e.g.

CW^1 -10^2- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

Table 4.6.2: Variation of CEC of waste amended JNU soil upon incubation

	Days of incubations							
CEC J	**0 days**	**10 days**	**20 days**	**30 days**	**45 days**	**60 days**	**90 days**	**120 days**
J-0-0	10.777	9.917	8.707	9.722	10.278	9.291	9.231	9.127
JM-10-0	8.8727	9.0967	10.604	11.591	11.81	11.81	11.179	11.179
JM-10-0.5	9.264	9.906	11.212	11.936	12.41	11.938	11.444	11.682
JM-101.0	9.7013	10.483	11.443	11.935	12.187	11.937	11.443	11.151
JM-20-0	9.563	10.187	11.221	11.95	12.396	12.396	11.947	11.453
JM-20-0.5	9.8027	11.109	12.167	11.437	11.679	11.935	11.935	11.656
JM-20-1.0	12.088	10.971	11.47	12.617	12.666	11.93	11.584	10.972
JM-30-0	12.395	11.593	11.693	12.865	12.861	12.199	11.82	11.223
JM-30-0.5	12.885	11.898	13.343	13.629	12.675	12.415	11.814	11.814
JM-30-1.0	11.25	11.019	10.287	11.119	11.606	10.983	10.835	10.781
JS-10-0	9.171	11.448	11.568	11.889	11.568	10.945	10.389	10.327
JS-10-0.5	8.742	9.903	11.119	11.976	11.591	11.467	10.937	10.487
JS-10-1.0	8.7173	9.8783	10.199	11.097	10.99	10.28	10.912	10.7
JS-20-0	10.731	10.373	11.614	11.622	10.991	10.289	9.5267	9.5267
JS-20-.5	10.728	10.486	12.001	11.459	11.69	10.854	10.286	9.881
JS-20-I.0	10.736	11.675	12.136	11.686	11.954	11.003	10.862	9.8887
JS-30-0	9.474	11.654	11.474	11.26	11.712	11.01	10.876	10.216
JS-30--0.5	9.654	11.663	12.156	12.375	11.942	11.613	10.97	10.722
JS-30-1.0	10.72	11.902	12.631	12.878	12.85	11.809	10.98	10.966
JW-10-0	11.948	12.685	12.919	12.986	12.865	12.773	12.773	11.745
JW-10-0.5	10.657	11.871	12.796	12.765	12.796	12.57	12.087	11.888
JW-10-1.0	11.142	11.151	10.437	11.598	11.922	11.436	11.136	10.738
JW-20-0	12.405	11.866	11.746	12.604	12.832	12.392	12.201	11.791
JW-20-.5	12.767	11.974	12.114	13.662	13.359	12.857	12.417	11.816
JW-20-I.0	12.484	11.572	11.001	12.88	12.878	12.124	11.571	10.984
JW-30-0	13.32	12.856	13.212	13.582	13.764	13.36	12.741	11.87
JW-30—0.5	13.829	13.283	13.776	11.527	11.417	10.691	10.147	10.953
JW-30-1.0	12.942	13.349	13.841	11.625	11.482	10.756	10.212	11.018

(All the values are mean of three replicas)

Abbreviation

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste; S-Summer waste .

Notation e.g.

JW^1 -10^2- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

4.7 AVAILABLE SULFUR (water Extractable Sulfate)

Sulfur is also an essential plant nutrient; being primarily taken-up in the form of SO_4^2 anions. The quantities of soluble sulfate in soils vary-widely both between soil types and within soil profiles. Large seasonal and year-to-year fluctuations levels of soluble sulfate in the surface soil and at greater depths can occur. This variability is caused by the interaction of environmental and seasonal conditions on the mineralization of organic sulfur, either downward or upward movement of sulfate salts in soil moisture, and sulfate uptake by plants. Sulfate content of soils is also affected by the application of sulfur-containing fertilizers, and the sulfate present in precipitation and irrigation waters. In localized areas near centers of industrial activity, direct absorption of SO_2 and the fallout of dry particulates can increase the sulfate content of soils. Because of its anionic nature and the solubility of most of its common salts, Sulfate like nitrate can, under conditions of large amounts of percolating water, be readily leached from the surface soil.(Cronan et al 1978, Johnson and Cole, 1980, Singh et al, 1980, Foster et al 1989,David et al 1991a). However its tendency to disappear from soils varies widely. Lowered soil solution SO_4^{2-} concentrations and increased pH, competition with organic compound and anions such as phosphate are the some of the important factors that governs the release of soluble sulfate in the soil solution.

When Chhattarpur soil (Table 4.7.1) was kept for incubation, the value of Available Sulfate (initially 0.9 ppm) increased over the time. There is transformation of sulfur from other form to sulfate forms by microbes as well as due to slow oxidation process. However by 90 days it attains stable conditions. Incase of JNU soil (initially 0.711ppm); highest value of available sulfate is achieved at JNU at 45th day of incubation (1.322ppm) (table 4.7.2). The value decreases afterwards (1.075 ppm at 60th day of Incubation) and attains a stable condition. After the completion of Incubation Available Sulfate of the JNU soil increased by 48.7 %(from 0.711 to 1.057ppm) and that of Chhattarpur soil increased by 85% (from 0.9ppm to 1.671ppm).

When the waste was added to Chhattarpur soil there has been an increase in the available sulfate concentration of the mixture, which was dependent on the nature of the season of collection. For 10% waste amended Chhattarpur soil, the increase was found to be maximum in case of summer (4.995ppm) followed by winter waste amended soil (4.708 ppm) and monsoon waste amended soil has the least (3.530 ppm) (Table 5.8.1). However in case of JNU soil for 10% Summer waste amended soil showed the maximum increase (5.092 ppm) followed by monsoon waste amended soil (4.933 ppm) and the winter waste amended soil (3.541ppm) (Table 5.8.2). With the increase of the percentage of waste the sulfate concentration also increases since the waste contains very high concentration of sulfate ions. Thus maximum concentration was obtained with 30% of waste.

With liming the release of adsorbed sulfate form the soil particle has been promoted, as the adsorbed form is converted into free (available) form. With increase in the 0.5 % of lime treatment there has been found an increase in the Sulfate concentration of the soil waste mixture. 0.5% liming increases the sulfate content of the JNU soil-waste mixture in the range of 1.3-17%. For Chhattarpur soil in case of 30% monsoon waste amendment, 0.5% lime treatment increases the sulfate by 1.6%(minimum i.e. from10.655ppm to 10.833ppm), where as for 20% summer waste amended soil it was 33%(maximum i.e 6.759ppm to 9.45ppm.) Similarly maximum mobilization of the sulfur has been observed in case of 10% Summer waste amended JNU soil(from 5.092 ppm to5.962 ppm) and the minimum increase was observed in case of 20% winter waste (from 8.863ppm to 8.986 ppm)amended soil. Similar results were obtained by Marsh et al (1987).

However when the 1% lime amendment of the waste is considered the maximum increase was observed in case of 20% winter waste amended Chhattarpur soil (by 45 %) and10% winter waste amended JNU soil (by 48%). Minimum increase is obtained in case of 30 % winter waste amended Chhattarpur soil (by 5.4%) as well as in case of 20% winter waste JNU soil.

When the soil – waste mixture was subject to incubation for 120 days, an increase has been observed in the available sulfate concentration. Maximum Values are observed at 45 to 60 days of incubation for Chhattarpur soil as well as JNU soil. The Value attains stable conditions afterwards.

When the overall change in the concentration of the available sulfate was considered, it was observed that 0% lime treated 10% monsoon waste amended monsoon waste Chhattarpur soil showed maximum increase in the available sulfate. i.e. by 258 % (from 3.50ppm to 12.663ppm) . The increase was least in case of 0.5% lime treated 30 % monsoon waste amended soil. i.e. by 30%(from 10.833 to 14.114ppm). Similarly in case of JNU soil, maximum increase (229%)

was observed for 0 % lime treated 10% winter waste amended soil (from 3.541 to 11.681ppm) and minimum increase was observed for1.0% lime treated soil and 30% monsoon waste amended i.e. by 40% (from 13.845ppm to 19.428ppm).similar results were obtained by Fuller1985

The ANOVA of the Available Sulfate variation of JNU soil and Chhattarpur soil was carried out, considering 'percentage of waste', 'lime treatment', 'days of Incubation' and 'Replications'. The 'replication' were ~~not~~ found to be non significant for both type of soil. The adjusted R^2 Value was 0.9111 in case of Chattarpur soil and 0.9370 incase of JNU soil.

Table 4.7.1 Variation of available sulfate of waste amended Chhattarpur soil upon incubation

	Days of incubation							
Samples	**0 days**	**10 days**	**20days**	**30 days**	**45 days**	**60 days**	**90 days**	**120 days**
C-0-0	0.9	0.987	1.11	1.255	1.142	1.508	1.668	1.671
CM-10-0	3.530	3.688	3.890	5.557	5.5047	11.794	10.68	12.663
CM-10-0.5	4.504	4.565	4.983	6.583	14.197	8.714	11.152	13.284
CM-101.0	4.783	5.266	6.219	9.9695	13.994	13.634	14.72	11.775
CM-20-0	6.03	7.223	9.457	8.732	18.364	18.057	12.68	18.399
CM-20-0.5	6.079	6.789	9.803	10.338	18.317	17.396	12.328	17.869
CM-20-1.0	7.259	7.873	8.519	13.488	19.119	17.82	12.341	17.987
CM-30-0	10.655	11.953	10.818	8.5455	19.339	19.173	14.702	19.059
CM-30-0.5	10.833	10.526	9.04	9.741	19.114	19.57	14.886	14.114
CM-30-1.0	11.542	11.489	11.196	10.251	14.726	19.533	15.451	20.165
CS-10-0	4.995	8.425	9.809	6.948	15.1	13.416	11.111	14.767
CS-10-0.5	5.15	4.772	4.938	8.825	13.13	14.378	13.091	15.229
CS-10-1.0	5.432	6.239	6.326	8.193	17.475	14.616	12.989	15.195
CS-20-0	6.759	6.330	6.618	12.282	19.664	19.173	11.054	18.374
CS-20-.5	9.045	8.678	6.852	16.958	17.407	19.108	15.502	16.81
CS-20-1.0	9.089	8.949	6.229	12.616	19.327	18.336	16.408	18.046
CS-30-0	9.595	8.271	12.691	14.344	8.7	12.946	13.056	20.007
CS-30--0.5	10.622	10.807	12.674	14.756	20.017	19.894	13.858	19.71
CS-30-1.0	12.294	12.293	12.933	15.133	11.565	20.32	14.105	18.925
CW10-0	4.705	4.927	4.733	5.944	10.497	14.225	12.856	11.576
CW-10-0.5	5.021	5.931	4.547	6.172	15.118	13.057	12.656	14.162
CW-10-1.0	6.313	5.769	4.875	5.654	3.006	13.304	12.782	12.462
CW-20-0.0	5.977	6.109	7.012	14.233	18.521	13.652	12.816	19.495
CW-20-0.5	8.335	8.335	6.493	10.882	16.862	14.897	11.791	15.414
CW-20-1.0	8.710	8.657	6.052	10.935	11.017	16.297	14.015	19.446
CW-30-0.0	9.813	8.962	9.137	13.049	12.323	18.051	14.568	16.744
CW-30-0.5	10.273	8.774	7.809	12.566	13.152	18.696	15.298	17.108
CW-30-1.0	10.345	10.673	8.814	12.777	15.963	18.708	17.217	17.551

(All the value are mean of three replicas)

Abbreviation

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste; S-Summer waste .

Notation e.g.

JW^1 -10^2- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

a A

Table 4.7.2 Variation of Available Sulfate in waste amended JNU soii upon incubation.

	Days of incubation							
Samples	**O days**	**10 days**	**20days**	**30 days**	**45 days**	**60 days**	**90 days**	**120 days**
J-0-0	0.711	0.856	0.838	1.220	1.322	1.075	1.084	1.057
JM-10-0	4.933	5.229	6.840	9.328	10.342	11.654	11.75	11.338
JM-10-0.5	5.111	7.113	11	11.804	11.21	11.094	11.241	12.425
JM-101.0	5.112	6.715	7.839	8.323	11.34	11.353	11.378	10.34
JM-20-0	8.268	8.15	9.729	10.935	16.004	17.504	18.267	18.25
JM-20-0.5	9.012	11.448	11.48	9.844	13.542	17.922	17.527	18.08
JM-20-1.0	9.223	11.439	11.343	15.471	13.443	17.636	17.847	18.092
JM-30-0	10.86	15.231	13.845	17.54	14.252	18.05	16.059	18.374
JM-30-0.5	10.88	12.233	13.707	17.539	14.442	17.605	16.667	19.175
JM-30-1.0	13.84	13.667	13.609	17.727	19.579	19.498	13.13	19.428
JS-10-0	5.092	7.645	9.258	11.83	11.96	14.328	16.434	13.767
JS-10-0.5	5.962	7.019	10.947	13.26	14.041	14.237	14.43	13.641
JS-10-1.0	6.688	8.344	9.879	12.783	13.342	12.467	12.747	12.686
JS-20-0	8.150	9.015	11.145	10.223	14.26	17.822	16.243	18.62
JNS-20-.5	8.517	9.91	12.652	9.8615	8.688	17.863	18.424	18.722
JS-20-I.0	8.774	9.684	13.037	12.239	14.523	18.116	18.274	18.274
JS-30-0	10.00	12.79	13.876	13.127	15.401	19.595	20.13	19.718
JS-30—0.5	10.24	11.487	13.824	17.729	15.68	19.166	19.762	19.92
JS-30-1.0	11.21	14.6	14.109	13.182	15.553	19.644	19.934	19.565
JW10-0	3.541	4.806	5.61	4.211	8.0263	10.058	8.3563	11.681
JW-10-0.5	4.079	5.831	7.441	11.547	11.236	11.092	10.171	10.127
JW-10-1.0	5.279	6.062	7.399	10.202	10.901	9.822	11.383	10.111
JW-20-0.0	8.863	12.88	12.643	13.404	13.512	18.275	15.609	16.065
JW-20-0.5	8.986	9.116	11.194	10.646	13.058	16.081	16.634	15.923
JW-20-1.0	9.045	8.445	11.253	13.345	12.997	15.517	15.903	15.367
JW-30-0.5	9.295	10.342	13.268	14.212	15.117	17.349	17.647	17.744
JW-30-0.0	9.952	11.084	12.87	14.025	15.004	13.17	17.345	18.161
JW-30-1.0	9.961	9.7783	13.418	10.709	16.015	17.91	17.665	18.015

(All the values are mean of three replicas)

Abbreviation

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste; S-Summer waste .

Notation e.g.

JW^1 -10^2- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

Adsorbed

4.8 TOTAL SULFATE (PHOSPHATE EXTRACTABLE)

Total sulfate comprises of the adsorbed sulfate and the available sulfate of the soil .Adsorbed sulfate is an important fraction of sulfur present in soil, which governs the release of available sulfate. Sulfate gets adsorbed on the soil particle and is released over a longer period of time. Factors affecting sulfate adsorption include pH (Kamprath et al. 1956; Parfitt, 1982), type of cation present (Chao et al., 1963), presence of competing anions (Chao, 1964; Pa.rfitt, 1982), extractable Al and Fe fractions (Chao et al., 1964; Barrow, 1967; Singh, 1980; Johnson and Todd, 1983; Fuller et al., 1985), extractable Sulfate (Metson and Blakemore, 1978), organic C (Singh, 1984; Evans, 1986), clay content (Chao et aL.1962), and soil horizon type (Singh, 1980; Johnson and Todd. 1983; Fuller et al., 1985; Weaver et al., 1985).

JNU soil (1.489ppm)(table no4.8.1) has lower total sulfate content then Chhattarpur soil(1.781ppm). (table no4.8.2).When Chhattarpur soil as well as JNU soil was kept for incubation, the value of total sulfate increased over the time. In both case, maximum value are obtained after 90days of incubation in (2.832ppm and 2.705ppm) for JNU soil and Chhattarpur soil respectively). After the completion of Incubation period total Sulfate of the JNU soil increased by 57.6%(2.347ppm from 1.489ppm)and that of Chhattarpur soil increased by 50.5 % (1.781 ppm to 2.682 ppm). There is transformation of sulfur from other form to sulfate forms by microbes as well as due to slow oxidation

When the waste was added to soil there has been an increase in the total sulfate concentration of the mixture, which was dependent on the nature of the season of collection and the type of the soil. For 10% waste amended Chhattarpur soil the increase was found to be maximum in case of monsoon waste (11.446ppm), followed by summer waste amended soil (9.859ppm) and winter waste amended soil has the least (6.756ppm). However in case of JNU soil, 10% Monsoon waste amended soil showed the maximum increase (6.487ppm) followed by winter waste amended soil (4.607ppm) and the summer waste amended soil (3.900ppm). With the increase of the percentage of waste the sulfate concentration also increases since the waste contains very high concentration of sulfate ions. Thus maximum concentration was obtained with 30% of waste.

Liming was observed to facilitate the mineralization. Also ~~As well as~~ the Microbial activities caused the transformation of organic fraction to inorganic sulfur. When the waste were treated with 0.5 % of lime and added to soil, there has been found an increase in the Sulfate concentration of the soil waste mixture. 0.5% liming increases the sulfate content of the JNU soil-waste mixture in the range of 0.7-35% and for Chhattarpur soil the range of increase is 0.6%-23%. . Maximum mineralization of the sulfur has been observed in case of 0.5 % lime treated 20% monsoon waste amended Soils (both JNU and Chhattarpur). The increase is 35% (from 13.381 to 17.795ppm) and 23% (from 19.147 to 23.727ppm) for JNU Soil and Chhattarpur soil respectively. Minimum increase for 0.5% treatment of lime to waste was observed for 30% winter waste amended soil. An increase by 0.7% for JNU soil (from38.552ppm to 38.824ppm) and 0.6% for Chhattarpur soil (from 44.572ppm to 44.844) has been observed.

However when the 1% lime amendment of the waste is considered, maximum increase was observed in case of 20% monsoon waste amended Chhattarpur soil i.e by 27 % (from 19.147ppm to 24.497ppm) as well as in the case of 10% summer waste amended JNU soil i.e. by 47% (from 3.9ppm to 5.744ppm). Minimum increase is obtained in case of 30 % monsoon waste amended Chhattarpur soil i.e. by 0.8%(from 38.377ppm to38.71 ppm) as well as in case of 30% summer waste amended JNU soil i.e .by 8%(from 38.552 to 41.925ppm).

When the soil – waste mixture was subject to incubation for 120 days, it has been found that an increase in the Total sulfate concentration. Maximum Values are observed at 45-60 days of incubation for Chhattarpur soil as well as JNU soil. A stable condition is obtained afterwards.

When the overall change in the concentration of the Total sulfate was considered, it was observed that 1.0 % lime treated 10% monsoon waste amended Chhattarpur soil showed minimum increase in the Total sulfate i.e. by 2.7 % (from13.77 ppm to14.143 ppm) The 0% and 1.0% lime treatment of 30% summer waste amended soil showed an increase from initial value by123%(from 6.932ppm to15.455 ppm). Similarly in case of JNU soil, maximum increase (by 327%) was observed for 10% summer waste amended 0 % lime treated soil (from 3.9 to 16.676ppm) and minimum increase was observed for 20% monsoon waste amended and 1.0% lime treated soil i.e. by 42% (from 18.559 ppm to

27.753ppm).This indicates that sulfur have been mineralized from organic sulfur or have been oxidized from other forms to Sulfate forms. Similar results have Obtained by Nor (1977).

Average values

For Chhattarpur soil the average value of total sulfate increase over the time. There is transformation of sulfur from other form to sulfate forms by microbes or due to slow oxidation process. Which ultimately get stabilized towards the end of incubation period. A peak has been observed at 90th day (Table 5.9.1) With liming the mineralization of sulfur has been promoted. With increase in the % of lime treatment there has been found an increase in the Sulfate concentration of the soil waste mixture.

When the rate of increases of total sulfate was observed against the days of incubation, it was observed that overall rate of increase was found to be maximum in case of 0% lime treated 20% waste amended chattarpur soil as well as in case of 1.0% lime treated, 20% waste amended JNU soil. The rate of increase of total sulfate was found to be was found to be minimum in 1% lime treated and 30% waste amended Chhattarpur spoil as well as JNU soil

The ANOVA of the Total sulfate variation of JNU soil and Chhattarpur soil was carried out, considering percentage of waste, lime treatment, days of Incubation and Replications. The variables 'replication' was not found to be significant for both type of soil. However in case of JNU soil, the lime treatment was also found to be non significant. The adjusted R^2 Value was 0.8073 in case of Chattarpur soil and 0.9547 incase of JNU soil.

Table 4.8.1 variation of total Sulfate of waste amended chattarpur soil upon incubation.

	Days of incubations							
Samples	**0d**	**10d**	**20d**	**30d**	**45d**	**60d**	**90d**	**120d**
C-0-0	1.781	1.876	1.671	2.357	2.182	2.652	2.705	2.682
CM-10-0	11.446	9.6077	12.295	14.688	15.877	11.885	11.533	12.785
CM-10-0.5	12.757	14.085	17.129	19.165	22.562	17.667	13.746	13.726
CM-101.0	13.77	13.248	14.442	15.762	17.606	13.634	14.618	14.143
CM-20-0	19.147	22.213	24.362	24.837	30.273	28.422	27.486	25.198
CM-20-0.5	23.727	24.768	22.858	27.882	36.768	31.753	26.34	28.947
CM-20-1.0	24.497	26.077	29.062	34.926	36.883	31.808	29.738	30.494
CM-30-0	38.377	41.618	38.693	45.076	47.767	46.872	41.219	41.678
CM-30-0.5	38.584	41.552	38.269	43.882	49.075	46.806	42.527	41.134
CM-30-1.0	38.71	39.222	42.386	49.016	52.117	43.879	41.749	41.849
CS-10-0	9.859	10.229	17.094	17.353	16.676	19.124	18.29	18.302
CS-10-0.5	10.872	16.197	18.406	14.987	14.048	17.152	16.393	16.675
CS-10-1.0	11.801	12.948	12.053	14.689	21.306	18.56	17.98	17.784
CS-20-0	16.823	18.931	20.006	25.136	28.364	23.946	28.977	27.349
CS-20-.5	17.774	18.749	21.998	21.241	26.899	25.466	24.468	26.869
CS-20-I.0	18.617	20.19	29.384	31.286	32.668	27.295	28.564	27.235
CS-30-0	44.572	47.01	42.413	44.241	51.488	58.801	59.893	60.368
CS-30--0.5	44.844	44.059	47.342	49.196	49.671	51.775	58.494	65.193
CS-30-1.0	47.941	47.279	48.831	48.36	55.354	57.637	58.967	56.801
CW10-0	6.7563	11.003	11.835	12.424	16.316	15.122	15.241	14.764
CW-10-0.5	6.9327	7.4557	13.068	14.752	19.695	15.098	15.815	15.456
CW-10-1.0	7.052	10.045	11.478	12.782	17.508	15.657	13.806	13.448
CW-20-0.0	13.812	19.738	20.992	27.11	33.231	34.723	24.813	29.708
CW-20-0.5	14.791	20.599	22.808	24.782	33.136	34.747	26.092	29.674
CW-20-1.0	17.114	18.447	18.626	27.11	29.551	29.85	28.715	27.581
CW-30-0.0	24.533	26.291	35.008	41.319	42.351	40.56	42.351	40.56
CW-30-0.5	26.744	29.281	35.311	37.319	41.819	41.699	37.281	37.162
CW-30-1.0	28.658	26.958	28.511	30.394	34.302	32.69	34.003	35.137

(All the values are mean of three replicas)

Abbreviation

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste; S-Summer waste .

Notation e.g.

JW^1 -10^2- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

Table. 4.8.2: Variation of total Sulfate of waste amended JNU soil upon incubation

	Days of Incubations							
Samples	**0days**	**10days**	**20days**	**30days**	**45days**	**60days**	**90days**	**120days**
J-0-0	1.489	1.563	2.608	2.512	1.926	2.291	2.832	2.347
JM-10-0	6.487	8.055	11.145	13.874	13.429	11.956	12.921	14.086
JM-10-0.5	6.801	7.219	11.458	13.439	12.234	16.67	16.159	17.159
JM-101.0	7.816	8.576	9.307	11.946	13.904	13.468	11.397	16.054
JM-20-0	13.181	18.75	19.885	24.931	34.511	34.264	31.228	33.825
JM-20-0.5	17.795	20.052	26.082	23.767	31.992	29.44	30.35	27.753
JM-20-1.0	18.559	16.166	21.36	24.603	29.36	29.463	32.032	26.494
JM-30-0	31.282	35.588	35.707	48.006	48.752	47.276	55.648	48.603
JM-30-0.5	32.657	35.522	35.284	46.006	55.881	53.336	63.284	65.672
JM-30-1.0	34.812	33.192	39.401	31.021	31.64	43.887	57.252	56.655
JS-10-0	3.9	4.199	11.109	13.046	12.016	13.536	17.154	16.676
JS-10-0.5	4.814	6.164	10.429	12.157	13.242	13.878	14.749	13.749
JS-10-1.0	5.7443	6.9183	9.068	11.482	14.152	13.225	12.52	12.95
JS-20-0	10.777	12.722	13.976	29.446	24.695	21.64	40.231	23.59
JNS-20-.5	11.727	14.152	26.391	39.285	36.734	36.857	45.794	46.272
JS-20-1.0	12.56	12.907	17.026	38.479	44.31	44.698	49.683	50.459
JS-30-0	38.552	40.98	39.428	45.732	58.861	59.184	70.891	70.115
JS-30--0.5	38.824	38.029	44.357	31.822	54.551	58.342	64.238	72.319
JS-30-1.0	41.925	41.249	45.846	64.24	68.801	52.725	72.711	75.279
JW10-0	4.6073	6.973	8.361	11.972	10.227	16.161	18.749	16.853
JW-10-0.5	5.005	7.082	10.083	14.659	15.701	19.163	10.979	18.052
JW-10-1.0	5.1067	4.015	8.493	12.008	20.493	16.46	12.669	18.174
JW-20-0.0	9.9	12.395	15.619	25.077	37.32	28.442	25.47	24.992
JW-20-0.5	8.852	13.733	18.032	23.166	23.524	24.324	24.495	26.479
JW-20-1.0	11.158	14.566	19.82	21.256	36.357	24.638	24.994	28.507
JW-30-0	18.611	23.247	32.321	43.763	34.709	47.962	52.978	51.903
JW-30-0.5	20.815	20.267	32.028	43.763	37.162	39.19	57.759	59.61
JW-30-1.0	22.737	20.929	25.526	39.89	51.292	49.689	57.824	60.332

(All the values are mean of three replicas)

Abbreviation

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste; S-Summer waste .

Notation e.g.

JW^1 -10^2- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

4.9 TOTAL SULFUR

The sulfur in most arable land toady is in the form of organic matter soluble sulfate in soils solution, reduced form or adsorbed sulfate on the soil complex . It is present in soil in different form as well as in multiple oxidation states ranging from +6 in Sulfate ions to –2in Sulfide ions. A little fraction of the sulfate also exist as an elemental sulfur.

There is inter-conversion of various from into other due to microflora of the soil. The other form are readily converted into sulfate formby means of sulfur oxidizing Chemolithic sulfur bacteria (such as *Thiobacillii* group*(T.thioparus, T.copraliticus, T.ferrooxidans*),and *Arthrobactor* group. Various fungi (commonly *Actinomycetes) Alernaria tenuis*, *Aureobasidiuum pullulans* species have been found to have ability to oxidize sulfur.

The loss of sulfur has also been observed in soil where the organic matters more than 5 to 7 %. The volatilization causes the release of sulfur in form of various organic compounds e.g. carbon disulfide ($CS_{2=}$), methyl merchantman (CH_3SH), and/or diethyl disulfide (CH_3SSCH_3). The actual amounts of sulfur volatilized were very small and did not represent more than 0.05% of the total sulfur present in soil.

The total sulfur of either JNU soil or Chhattarpur soil showed no significant change from the original value. It showed slight decrease from the initial concentration towards 45-60 days after which it attains a stable value (Table 5.7.1 and table 5.7.2)

When the Chhattarpur soil is mixed with industrial waste, there is an increase in the total sulfur content of the soil waste mixture. The increase is found to be maximum for summer waste (36.938) followed by winter waste (33.438 ppm) and the monsoon waste soil mixture the change was least (33.213 ppm) for 10 % of the waste. (Table 4.7.1) However when the JNU soil is mixed with industrial waste, there is an increase in the total sulfur content of the soil waste mixture. The increase is found to be maximum for summer waste (37.229 ppm) followed by Monsoon waste (32.503 ppm) and the winter waste soil mixture the change was least (32.495ppm) for 10 % of the waste. Similar trends have been observed in case of 20% and 30% waste. (Table 4.7.2)

The ANOVA of the Total sulfate variation of JNU soil and Chhattarpur soil was carried out, considering 'percentage of waste', 'lime treatment;' 'days of

Incubation' and 'Replications'. The interaction between variables 'lime treatment' and 'days of Incubation' as well as 'waste percentage' and 'days of incubation' was not found to be significant for both type of soil. The adjusted R^2 Value was 0.9999 in case of Chattarpur soil and 0.9886 incase of JNU soil.

Table 4.9.1 Variation of total Sulfur of waste amended Chhattarpur soil upon incubation

	Days of incubation							
Samples	**0days**	**10days**	**20days**	**30days**	**45days**	**60days**	**90days**	**120days**
C-0-0	15.642	15.619	15.57	15.558	15.552	15.555	15.553	15.554
CM-10-0	33.213	33.196	33.044	33.124	33.126	33.129	33.127	33.128
CM-10-0.5	33.962	33.975	33.925	33.896	33.89	33.893	33.891	33.892
CM-101.0	34.801	34.728	34.628	34.638	34.356	34.521	35.543	35.454
CM-20-0	48.111	48.078	48	47.995	48	48.075	47.997	48.008
CM-20-0.5	49.951	49.934	49.484	49.84	49.464	49.547	49.555	49.484
CM-20-1.0	47.302	47.249	47.191	47.179	47.191	47.244	47.188	47.199
CM-30-0	68.358	68.372	68.321	68.298	68.286	68.289	68.287	68.288
CM-30-0.5	69.525	69.508	69.356	69.438	69.438	69.441	69.439	69.44
CM-30-1.0	68.525	68.508	68.356	68.437	68.438	68.441	68.439	68.44
CS-10-0	36.938	36.921	36.869	36.831	36.861	36.864	36.262	36.063
CS-10-0.5	38.439	38.422	38.27	38.361	38.352	38.355	38.353	38.354
CS-10-1.0	37.395	37.409	37.358	37.328	37.323	37.326	37.324	37.325
CS-20-0	56.304	56.318	56.267	56.244	56.233	56.236	56.234	56.235
CS-20-.5	56.404	56.417	56.367	56.342	56.332	56.335	56.333	56.334
CS-20-I.0	58.165	58.21	58.159	58.138	58.125	58.128	58.126	58.127
CS-30-0	76.072	76.038	75.96	75.967	75.96	76.035	75.957	75.968
CS-30--0.5	77.177	77.143	77.065	77.059	77.065	77.04	77.02	77.003
CS-30-1.0	77.804	77.771	77.692	77.685	77.692	77.567	77.541	77.47
CW10-0	33.438	33.405	33.336	33.39	33.336	33.401	33.333	33.334
CW-10-0.5	34.45	34.433	34.281	34.33	34.363	34.366	34.364	34.365
CW-10-1.0	35.107	35.09	34.938	35.028	35.02	35.023	35.021	35.022
CW-20-0.0	50.716	50.683	50.604	50.588	50.604	50.679	50.601	50.612
CW-20-0.5	50.49	50.457	50.378	50.374	50.378	50.453	50.375	50.386
CW-20-1.0	51.083	51.066	51.914	51.996	51.996	51.999	51.997	51.998
CW-30-0.0	67.866	67.88	67.829	67.784	67.795	67.798	67.796	67.797
CW-30-0.5	68.468	68.482	68.431	68.389	68.397	68.4	68.398	68.399
CW-30-1.0	66.967	66.981	66.93	66.92	66.895	66.898	66.896	66.897

Abbreviation ***(All the values are mean of three replicas)***

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste; S-Summer waste .

Notation e.g.

JW^1 -10^2- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

Table 4.9.2: variation of Total sulfur of waste amended JNU soil upon incubation

	Days of incubations							
Samples	**0days**	**10days**	**20days**	**30days**	**45days**	**60days**	**90days**	**120days**
J-0-0	14.847	14.753	14.678	14.713	14.681	14.686	14.678	14.675
JM-10-0	32.503	32.409	32.334	32.364	32.337	32.342	32.334	32.331
JM-10-0.5	33.502	33.408	33.35	33.378	33.336	33.341	33.333	33.33
JM-101.0	34.451	34.357	34.182	34.314	34.285	34.29	34.282	34.279
JM-20-0	50.168	50.074	50.016	50.035	50.002	50.007	49.999	49.996
JM-20-0.5	49.559	49.465	49.406	49.438	49.393	49.398	49.39	49.387
JM-20-1.0	51.55	51.456	51.281	51.42	51.384	51.389	51.381	51.378
JM-30-0	67.827	67.733	67.658	67.678	67.661	67.666	67.658	67.655
JM-30-0.5	68.165	68.071	67.996	68.022	67.999	68.004	67.996	67.993
JM-30-1.0	70.454	70.36	70.185	70.313	70.288	70.293	70.285	70.282
JS-10-0	37.229	37.137	37.077	37.14	37.063	37.068	37.06	37.057
JS-10-0.5	38.565	38.471	38.296	38.404	38.399	38.404	38.396	38.393
JS-10-1.0	40.757	40.663	40.605	40.635	40.591	40.596	40.588	40.585
JS-20-0	55.693	55.599	55.424	55.544	55.527	55.532	55.524	55.521
JNS-20-.5	56.116	56.022	55.847	55.97	55.95	55.955	55.947	55.944
JS-20-I.0	55.999	55.905	55.846	55.859	55.833	55.838	55.83	55.827
JS-30-0	76.129	76.035	75.96	75.961	75.963	75.968	75.96	75.957
JS-30--0.5	80.795	80.701	80.626	80.653	80.629	80.634	80.626	80.623
JS-30-1.0	79.45	79.356	79.298	79.326	79.284	79.289	79.281	79.278
JW10-0	32.495	32.401	32.326	32.215	32.329	32.334	32.326	32.323
JW-10-0.5	33.48	33.386	33.327	33.417	33.314	33.319	33.311	33.308
JW-10-1.0	34.445	34.376	34.318	34.326	34.304	34.309	34.301	34.298
JW-20-0.0	49.843	49.749	49.674	49.723	49.677	49.682	49.674	49.671
JW-20-0.5	50.547	50.453	50.378	50.402	50.381	50.386	50.378	50.375
JW-20-1.0	51.234	51.14	51.065	51.092	51.068	51.073	51.065	51.062
JW-30-0	67.336	67.242	67.167	67.23	67.17	67.175	67.167	67.164
JW-30-0.5	68.425	68.331	68.156	68.314	68.259	68.264	68.256	68.253
JW-30-1.0	69.489	69.395	69.22	69.313	69.323	69.328	69.32	69.317

(All the values are mean of three replicas)

Abbreviation

C-Chhattarpur soil; J-JNU soil; M –Monsoon Waste; W-winter waste; S-Summer waste .

Notation e.g.

JW^{1} -10^{2}- 0.5%^{3} :-1-type of soil and the waste(season); 2-percentage of the waste; 3- percentage of lime treatment ;

Table 5·1

ANOVA of pH of Chhattarpur soil

```
                         Number of obs =  648          R-squared     =  0.3706
                         Root MSE      = .638909       Adj R-squared =  0.2487

               Source | Partial SS    df       MS              F     Prob > F
         -------------+-----------------------------------------------------
                Model |  130.277733   105  1.24074031        3.04     0.0000
                      |
                Waste |  27.8207381     8  3.47759226        8.52     0.0000
       LIME TREATMENT |    4.791501     2  2.3957505         5.87     0.0030
                 DAYS |  19.4400707     7  2.77715296        6.80     0.0000
              REPLICA |  8.12220797     2  4.06110398        9.95     0.0001
  LIME TREATMENT*DAYS |  5.10836431    14  .364883165        0.89     0.5656
 LIME TREATMENT*waste |  9.13219689    16  .570762305        1.40     0.1367
           DAYS*waste |  55.8626536    56  .997547385        2.44     0.0000
                      |
             Residual |  221.246883   542   .40820458
         -------------+-----------------------------------------------------
                Total |  351.524615   647  .543314706
```

Table 5.2

ANOVA of pH of JNU soil

```
                           Number of obs =     648     R-squared     =  0.2907
                           Root MSE      = .224481     Adj R-squared =  0.1533

                  Source |  Partial SS    df       MS           F     Prob > F
            -------------+----------------------------------------------------
                   Model |   11.195497   105  .106623781       2.12     0.0000
                         |
                   waste |  4.15755749     8  .519694686      10.31     0.0000
          liME TREATMENT |  .265525466     2  .132762733       2.63     0.0727
                    DAYS |  1.02674246     7  .146677494       2.91     0.0054
                 REPLICA |  1.03155649     2  .515778247      10.24     0.0000
     LIME TREATMENT*DAYS |  1.08732717    14  .077666227       1.54     0.0920
    LIME TREATMENT*waste |  .659027556    16  .041189222       0.82     0.6662
              DAYS*waste |  2.96776033    56   .05299572       1.05     0.3787
                         |
                Residual |  27.3123638   542  .050391815
            -------------+----------------------------------------------------
                   Total |  38.5078608   647  .059517559
```

Table 5.3

ANOVA of EC Chhattarpur soil

```
                           Number of obs =     648     R-squared     =  0.1606
                           Root MSE      = 15.2237     Adj R-squared =  0.0020

                  Source |  Partial SS    df       MS              F     Prob > F
              -----------+----------------------------------------------------
                   Model |  24036.7299   105  228.921237         0.99     0.5190
                         |
                   waste |  1638.35526     8  204.794407         0.88     0.0309
          LIME TREATMENT |  427.471948     2  213.735974         0.92     0.0498
                    DAYS |  1485.30093     7  212.185847         0.92     0.4938
                 REPLICA |  450.493398     2  225.246699         0.97     0.3790
     LIME TREATMENT*DAYS |  3259.97835    14  232.855597         1.00     0.4468
    LIME TREATMENT*waste |  3765.62633    16  235.351645         1.02     0.4381
              DAYS*waste |  13009.5037    56  232.312566         1.00     0.4738
                         |
                Residual |   125614.26   542  231.760627
              -----------+----------------------------------------------------
                   Total |   149650.99   647  231.299829
```

Table 5.4

ANOVA of EC JNU soil

```
                           Number of obs =     648     R-squared     =  0.1615
                           Root MSE      = 15.2262     Adj R-squared =  0.0010

                  Source |  Partial SS    df       MS              F     Prob > F
            -------------+----------------------------------------------------
                   MODEL |  24199.7647   105  230.473949          0.99     0.5020
                         |
                   WASTE |  1807.71992     8   225.96499          0.97     0.0454
          LIME TREATMENT |  448.331874     2  224.165937          0.97     0.0380
                    DAYS |  1541.26672     7   220.18096          0.95     0.4675
                 REPLICA |  451.721151     2  225.860575          0.97     0.3781
     LIME TREATMENT*DAYS |  3236.91781    14  231.208415          1.00     0.4544
    LIME TREATMENT*WASTE |  3718.41065    16  232.400666          1.00     0.4523
              DAYS*WASTE |  12995.3965    56  232.060653          1.00     0.4766
                         |
                RESIDUAL |  125656.248   542  231.838097
            -------------+----------------------------------------------------
                   Total |  149856.013   647  231.616713
```

Table 5.5

ANOVA of organic carbon Chhattarpur soil

```
                         Number of obs =     648     R-squared     =  0.7941
                         Root MSE      = .093313     Adj R-squared =  0.7543

                  Source |  Partial SS    df       MS           F     Prob > F
      -------------------+-----------------------------------------------------
                   Model |  18.2063919   105  .173394209      19.91     0.0000
                         |
                   waste |  10.8847453     8  1.36059316     156.26     0.0000
          LIME TREATMENT |  .062508593     2  .031254296       3.59     0.0283
                    DAYS |  4.37330573     7  .624757961      71.75     0.0000
                 REPLICA |   .33502507     2  .167512535      19.24     0.0000
     LIME TREATMENT*DAYS |  .057631953    14  .004116568       0.47     0.9473
    LIME TREATMENT*waste |  .871231687    16   .05445198       6.25     0.0000
              DAYS*waste |  1.62194356    56  .028963278       3.33     0.0000
                         |
                Residual |  4.71934922   542  .008707286
      -------------------+-----------------------------------------------------
                   Total |  22.9257411   647  .035433912
```

Table 5.6

ANOVA of organic carbon of JNU soil

```
                         Number of obs =     648     R-squared     =  0.8383
                         Root MSE      = .100833     Adj R-squared =  0.8069

             Source |  Partial SS    df       MS           F     Prob > F
         -----------+----------------------------------------------------
              Model |  28.5609014   105  .272008584      26.75     0.0000
                    |
              waste |  21.1309629     8  2.64137036     259.79     0.0000
     LIME TREATMENT |  .201037757     2  .100518878       9.89     0.0001
               DAYS |  2.76513207     7  .395018867      38.85     0.0000
            REPLICA |  .359439463     2  .179719731      17.68     0.0000
LIME TREATMENT*DAYS |    .0374314    14  .002673671       0.26     0.9970
LIME TREATMENT*waste|  3.22763411    16  .201727132      19.84     0.0000
         DAYS*waste |  .839263672    56  .014986851       1.47     0.0174
                    |
           Residual |  5.51068266   542  .010167311
         -----------+----------------------------------------------------
              Total |   34.071584   647  .052660872
```

Table 5.7

ANOVA of CEC Chhattarpur

```
                              Number of obs =  648     R-squared     =  0.8301
                              Root MSE      = .78144    Adj R-squared =  0.7972

                    Source |  Partial SS    df       MS              F     Prob > F
              -------------+----------------------------------------------------
                     Model | 1616.78826    105  15.3979835       25.22     0.0000
                           |
                     WASTE |  315.662159     8  39.4577699       64.62     0.0000
            LIME TREATMENT |  34.8091692     2  17.4045846       28.50     0.0000
                      DAYS |  715.083399     7  102.154771      167.29     0.0000
                   REPLICA | 0.621654782     2  .310827391        0.51     0.6014
       LIME TREATMENT*DAYS |   31.455835    14  2.24684536        3.68     0.0000
      LIME TREATMENT*waste |  231.158156    16  14.4473848       23.66     0.0000
                DAYS*waste |   287.99789    56  5.14281946        8.42     0.0000
                           |
                  Residual |  330.971404   542  .610648346
              -------------+----------------------------------------------------
                     Total |  1947.75967   647  3.01044771
```

Table 5.8

ANOVA of CEC JNU soil

```
                      Number of obs =     648     R-squared     =  0.8770
                      Root MSE      = .401292     Adj R-squared =  0.8531

             Source |  Partial SS    df       MS            F     Prob > F
        ------------+----------------------------------------------------
              Model |  622.035653   105  5.92414908       36.79     0.0000
                    |
              waste |  198.114002     8  24.7642502      153.78     0.0000
     LIME TREATMENT |  9.59452093     2  4.79726047       29.79     0.0000
               DAYS |    137.0091     7  19.5727286      121.54     0.0000
            REPLICA |  .476299288     2  .238149644        1.48     0.2288
LIME TREATMENT*DAYS |  11.8898992    14  .849278516        5.27     0.0000
LIME TREATMENT*waste|  99.2517825    16   6.2032364       38.52     0.0000
         DAYS*waste |  165.700049    56  2.95892944       18.37     0.0000
                    |
           Residual |  87.2809587   542  .161034979
        ------------+----------------------------------------------------
              Total |  709.316612   647  1.09631625
```

Table 5.9

anova of Available sulfate of Chhattarpur soil

```
                           Number of obs =     648     R-squared     =  0.9255
                           Root MSE      = 1.37944     Adj R-squared =  0.9111

                  Source |  Partial SS    df       MS           F     Prob > F
              -----------+----------------------------------------------------
                   MODEL |  12814.3918   105  122.041827      64.14     0.0000
                         |
                   WASTE |  2661.65721     8  332.707152     174.85     0.0000
          LIME TREATMENT |  72.5954905     2  36.2977452      19.08     0.0000
                    DAYS |  8456.74133     7   1208.1059     634.89     0.0000
                 REPLICA |   .29812459     2  .149062295       0.08     0.9247
     LIME TREATMENT*DAYS |  198.508408    14   14.179172       7.45     0.0000
    LIME TREATMENT*WASTE |  237.987551    16  14.8742219       7.82     0.0000
              WASTE*DAYS |  1186.60369    56  21.1893516      11.14     0.0000
                         |
                RESIDUAL |  1031.34263   542  1.90284617
              -----------+----------------------------------------------------
                   Total |  13845.7344   647  21.3998987
```

Table 5.10

ANOVA of available sulfate of JNU soil

```
                      Number of obs =     648     R-squared     =  0.9473
                      Root MSE      = 1.00492     Adj R-squared =  0.9370

             Source |  Partial SS    df       MS              F     Prob > F
         -----------+-----------------------------------------------------
              Model |  9831.51275   105  93.6334548       92.72     0.0000
                    |
              waste |  3986.32301     8  498.290377      493.42     0.0000
     LIME TREATMENT |  16.6816533     2  8.34082665        8.26     0.0003
               DAYS |  5012.44262     7  716.063231      709.07     0.0000
            REPLICA |  .271815006     2  .135907503        0.13     0.8741
LIME TREATMENT*DAYS |  75.4751272    14  5.39108052        5.34     0.0000
LIME TREATMENT*waste | 132.504317    16  8.28151982        8.20     0.0000
         waste*DAYS |  607.814205    56  10.8538251       10.75     0.0000
                    |
           Residual |  547.349302   542  1.00986956
         -----------+-----------------------------------------------------
              Total |  10378.8621   647  16.0415179
```

Table 5.11

ANOVA of total sulfate of Chhattarpur soil

```
                    Number of obs =     648     R-squared     =  0.8386
                    Root MSE      = 6.05833     Adj R-squared =  0.8073

              Source |  Partial SS    df       MS           F     Prob > F
   ------------------+----------------------------------------------------
               Model |  103331.361   105    984.1082      26.81     0.0000
                     |
               waste |   78877.819     8  9859.72737     268.63     0.0000
      LIME TREATMENT |  31.5830655     2  15.7915327       0.43     0.0506
                DAYS |  6426.28805     7   918.04115      25.01     0.0000
             REPLICA |  7.79943026     2  3.89971513       0.11     0.8992
 LIME TREATMENT*DAYS |  2243.51051    14  160.250751       4.37     0.0000
LIME TREATMENT*waste |  4203.08811    16  262.693007       7.16     0.0000
          waste*DAYS |  11541.2728    56  206.094158       5.62     0.0000
                     |
            Residual |  19893.2295   542  36.7033754
   ------------------+----------------------------------------------------
               Total |   123224.59   647  190.455318
```

Table 5.12

ANOVA of total sulfate of JNU soil

```
                      Number of obs =     648     R-squared     =  0.9620
                      Root MSE      = 3.67982     Adj R-squared =  0.9547

            Source |  Partial SS    df       MS           F     Prob > F
-------------------+----------------------------------------------------
             Model |  186023.932   105  1771.65649      130.84     0.0000
                   |
             waste |  134242.506     8  16780.3133     1239.21     0.0000
    LIME TREATMENT |  177.154327     2  88.5771637        6.54     0.0016
              DAYS |  35393.2266     7  5056.17523      373.40     0.0000
           REPLICA |  35.9098229     2  17.9549115        1.33     0.2664
LIME TREATMENT*DAYS|  622.737662    14  44.4812616        3.28     0.0000
LIME TREATMENT*waste| 3973.32797    16  248.332998       18.34     0.0000
        waste*DAYS |  11579.0691    56   206.76909       15.27     0.0000
                   |
          Residual |  7339.26884   542  13.5410864
-------------------+----------------------------------------------------
             Total |  193363.201   647  298.861207
```

Table 5.13

ANOVA of Total sulfur of Chhattarpur soil

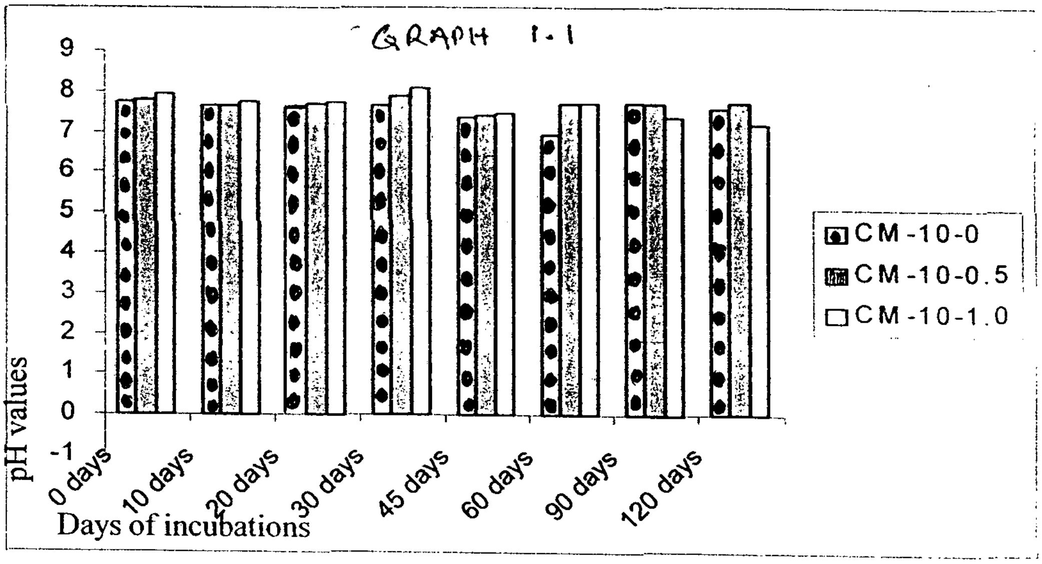
```
                         Number of obs =      648     R-squared     =  0.9999
                         Root MSE      =  .15127     Adj R-squared =  0.9999

              Source |  Partial SS    df       MS            F     Prob > F
          -----------+----------------------------------------------------
               Model |  142606.653   105   1358.1586   59353.50     0.0000
                     |
               Waste |  94244.0374     8  11780.5047  514825.12     0.0000
      LIME TREATMENT |   6443.3755     2  3221.68775  140792.42     0.0000
                DAYS |  .839956148     7  .119993735       5.24     0.0000
             REPLICA |  .986689265     2  .493344633      21.56     0.0000
 LIME TREATMENT*DAYS |  .012168826    14  .000869202       0.04     1.0000
  ME TREATMENT*waste |  41917.2832    16   2619.8302  114490.37     0.0000
          waste*DAYS |  .117604604    56  .002100082       0.09     1.0000
                     |
            Residual |  12.4023349   542  .022882537
          -----------+----------------------------------------------------
               Total |  142619.055   647  220.431306
```

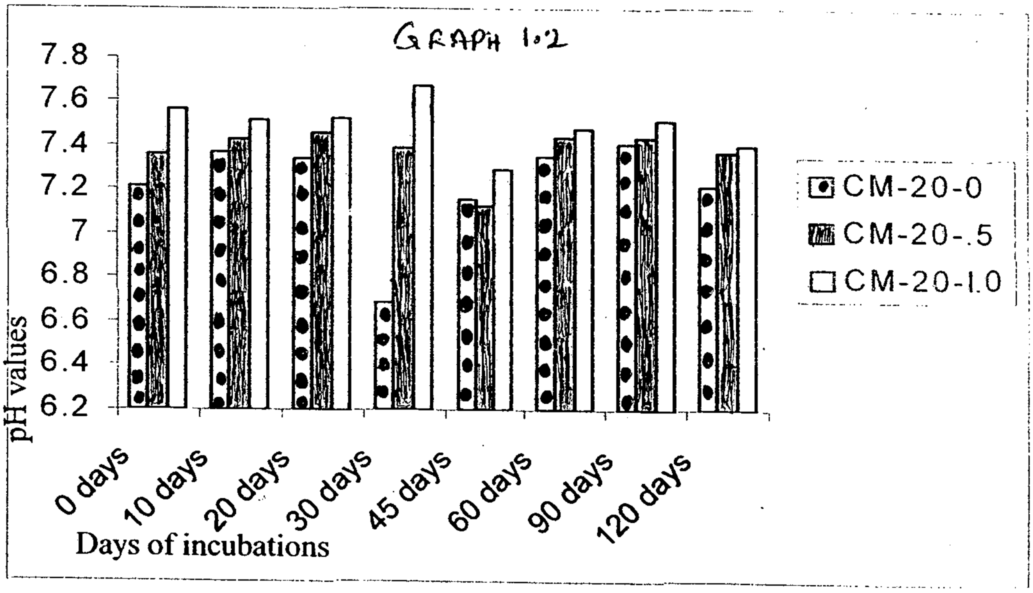
Table 5.14

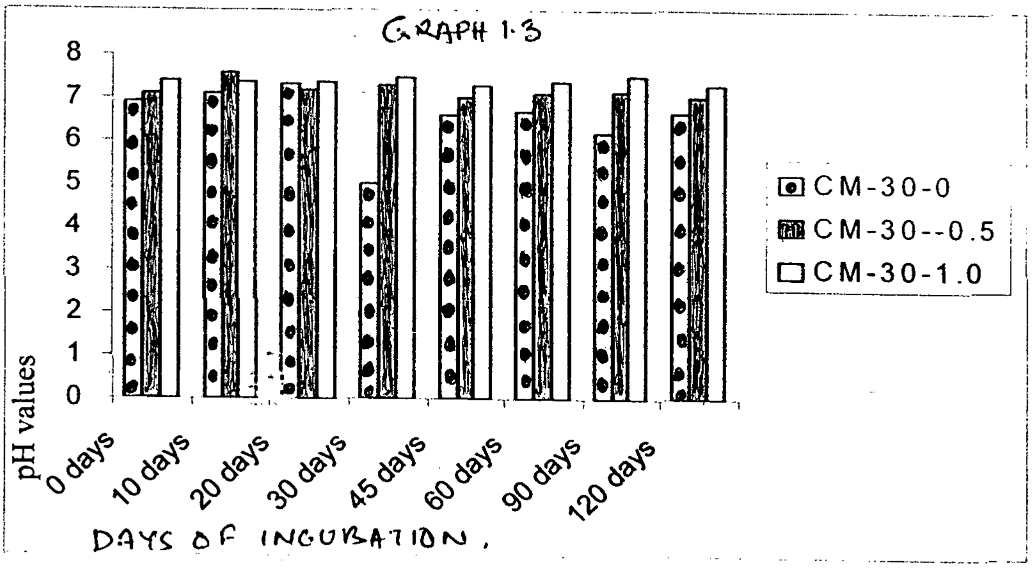
ANOVA of total Sulfur of JNU soil

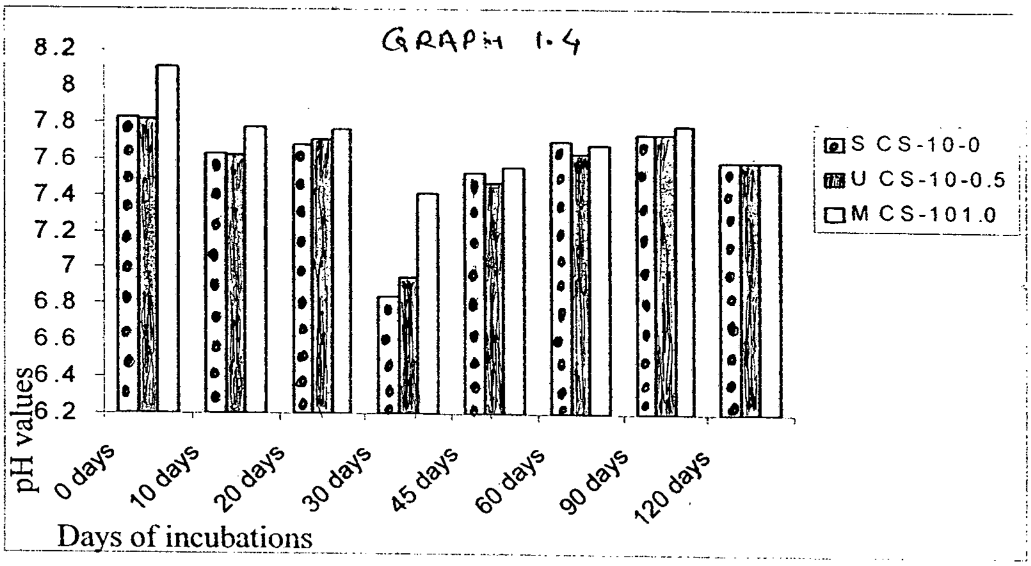
```
                      Number of obs =     648     R-squared     =  0.9904
                      Root MSE      = 1.64784     Adj R-squared =  0.9886

              Source |  Partial SS    df       MS           F     Prob > F
          -----------+----------------------------------------------------
               Model |  152253.452   105  1450.03287     534.01     0.0000
                     |
               waste |  150579.779     8  18822.4723    6931.78     0.0000
      LIME TREATMENT |   658.03763     2  329.018815     121.17     0.0000
                DAYS |  2.20476672     7  .314966674       0.12     0.0497
             REPLICA |  59.8315463     2  29.9157732      11.02     0.0000
 LIME TREATMENT*DAYS |  .011062508    14  .000790179       0.00     1.0000
LIME TREATMENT*waste |   953.53639    16  59.5960244      21.95     0.0000
          waste*DAYS |  .051381244    56  .000917522       0.00     1.0000
                     |
            Residual |  1471.74045   542  2.71538829
          -----------+----------------------------------------------------
               Total |  153725.192   647  237.596896
```

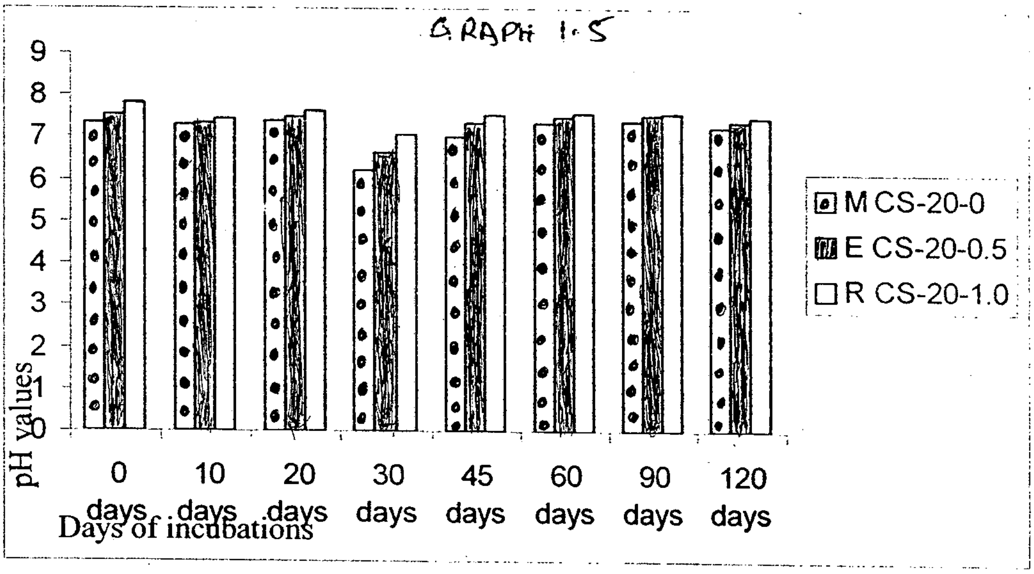
(5·1) *Variation of pH of Chhattarpur soil*

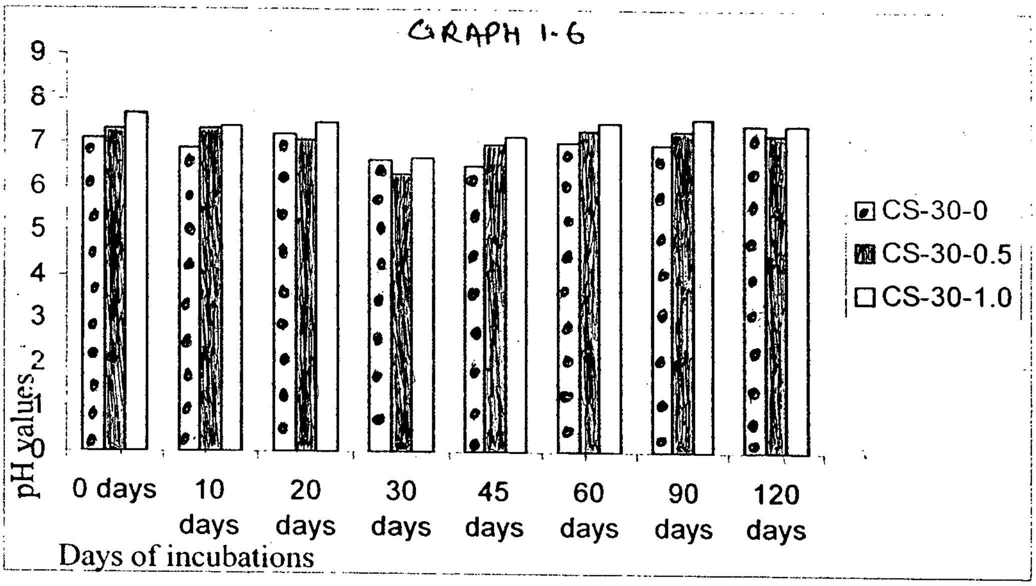




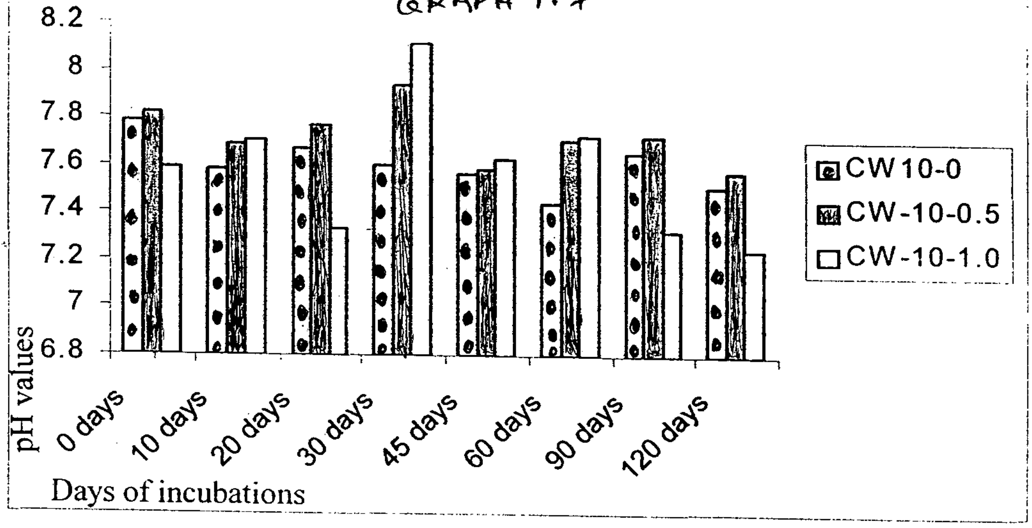



GRAPH 1.4

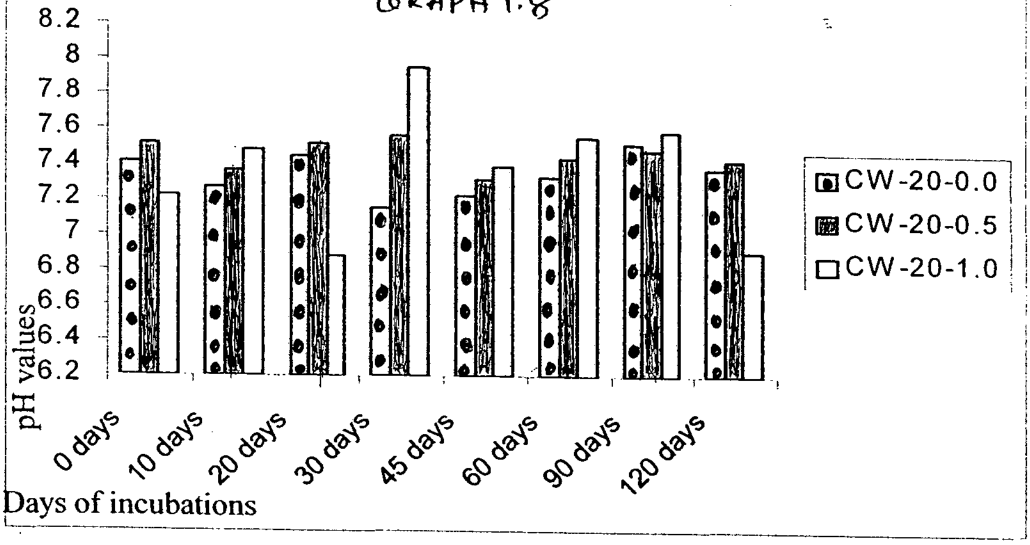

GRAPH 1.5


GRAPH 1.6

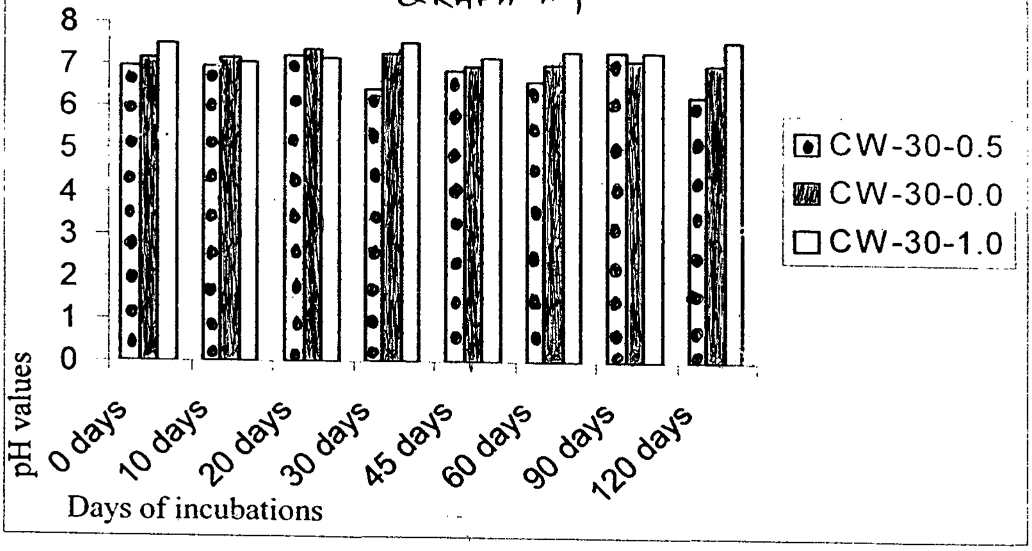
GRAPH 1.7



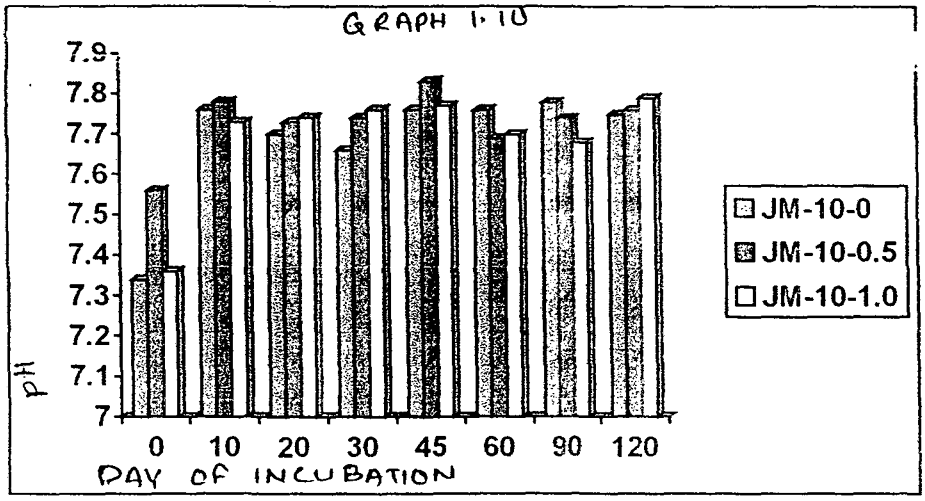
GRAPH 1.8



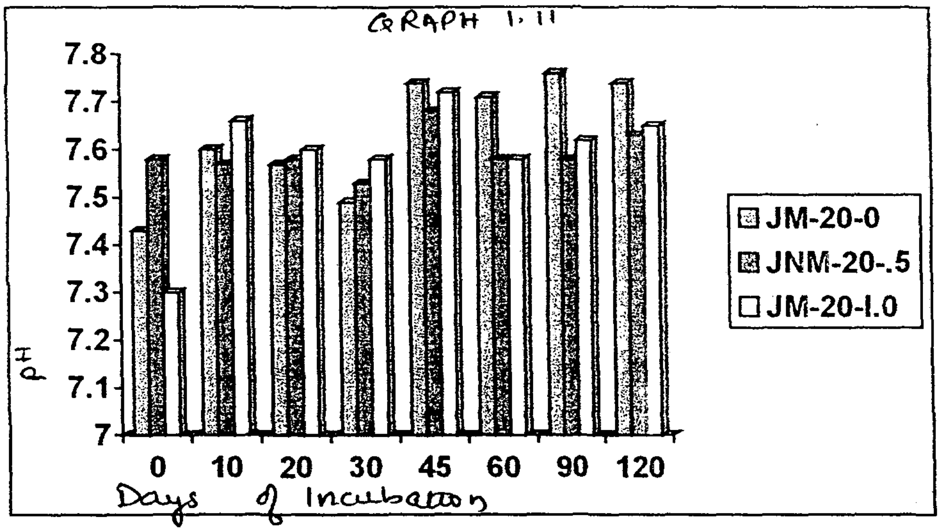
GRAPH 1.9



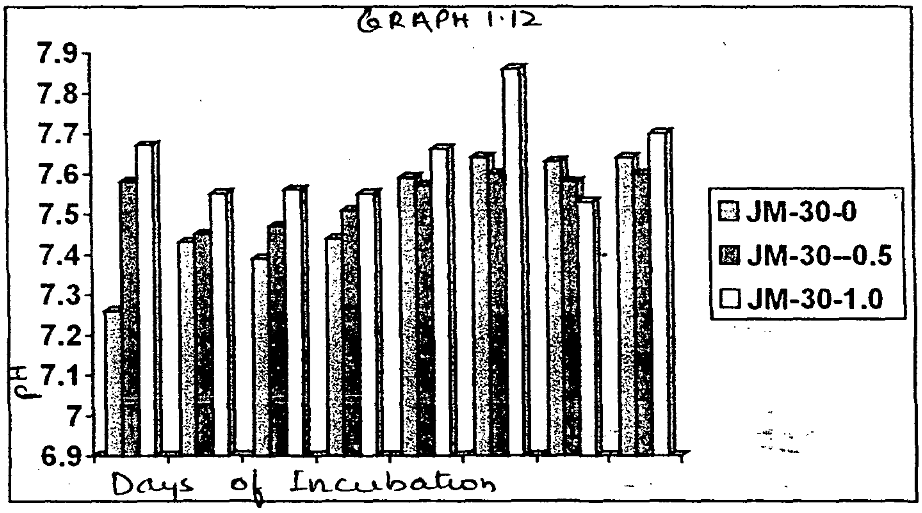
GRAPH 1.10

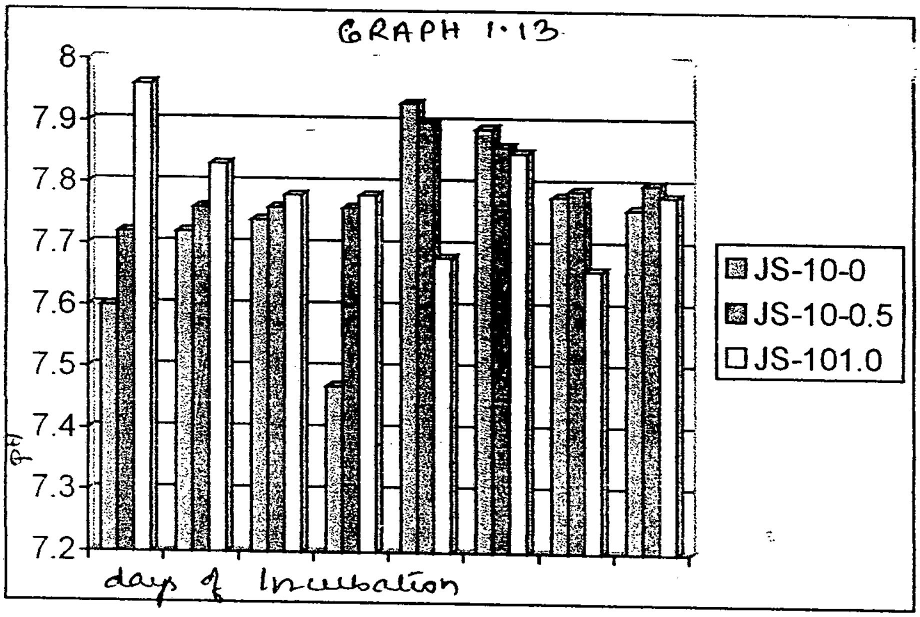


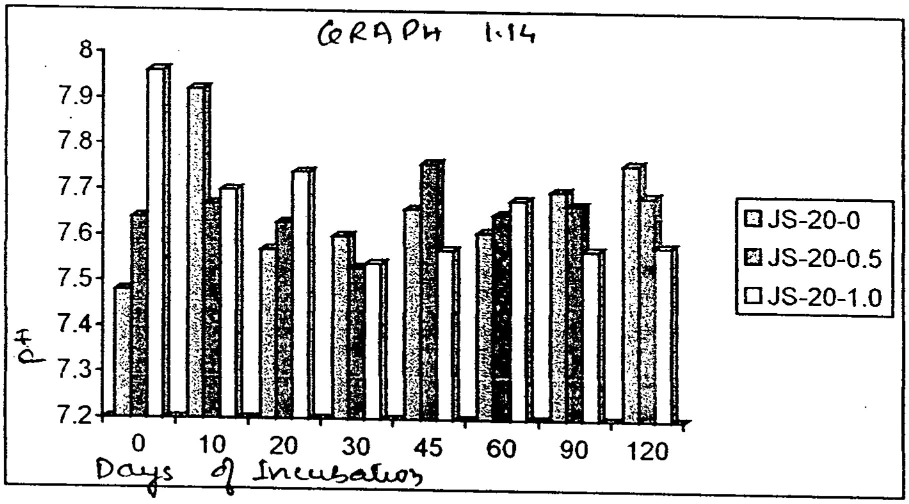
GRAPH 1.11

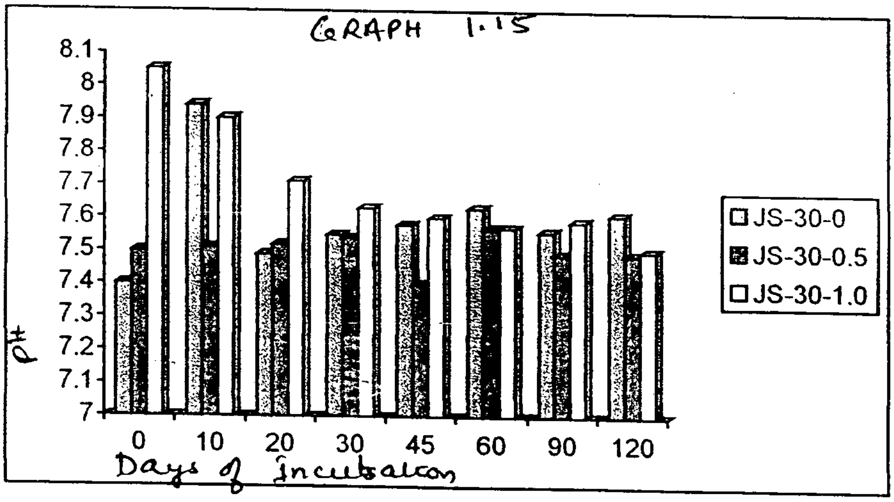


GRAPH 1.12

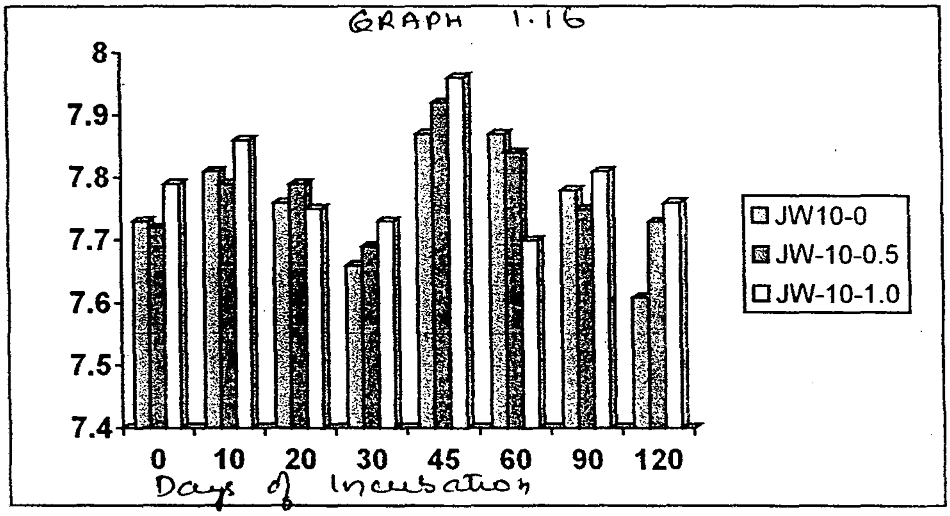



GRAPH 1.13

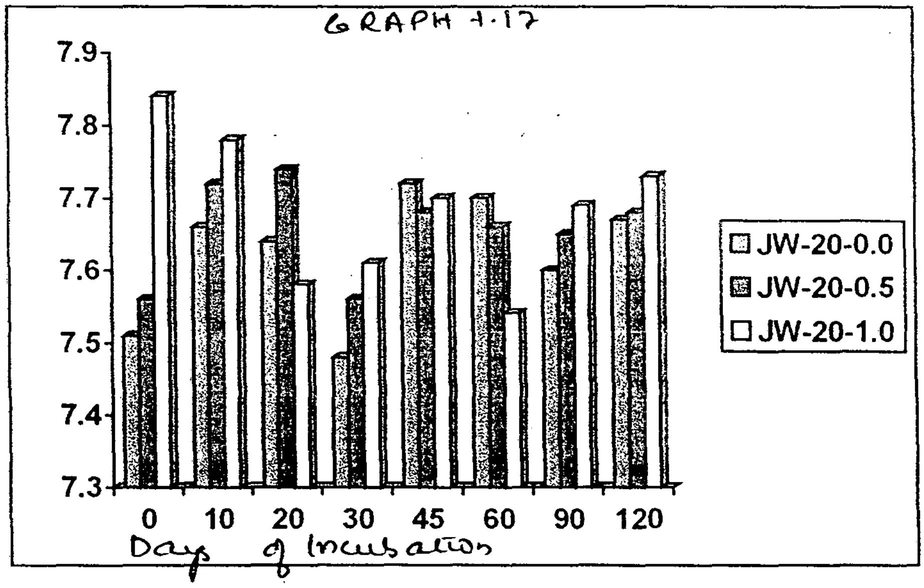

GRAPH 1.14


GRAPH 1.15

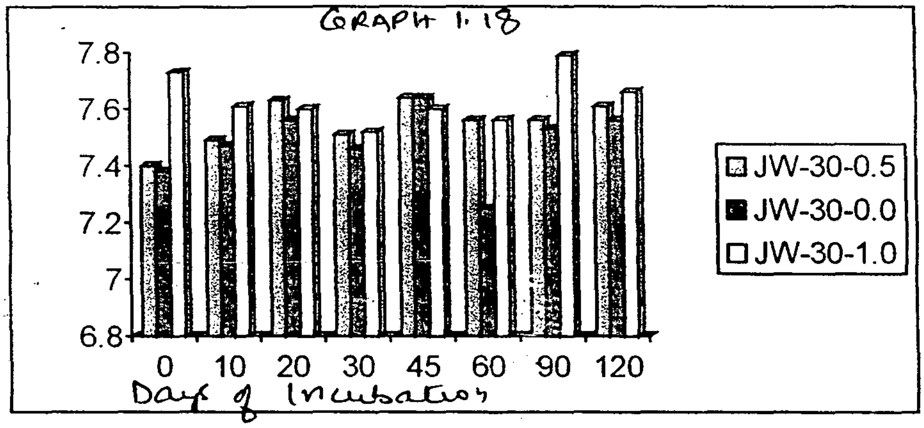
GRAPH 1.16

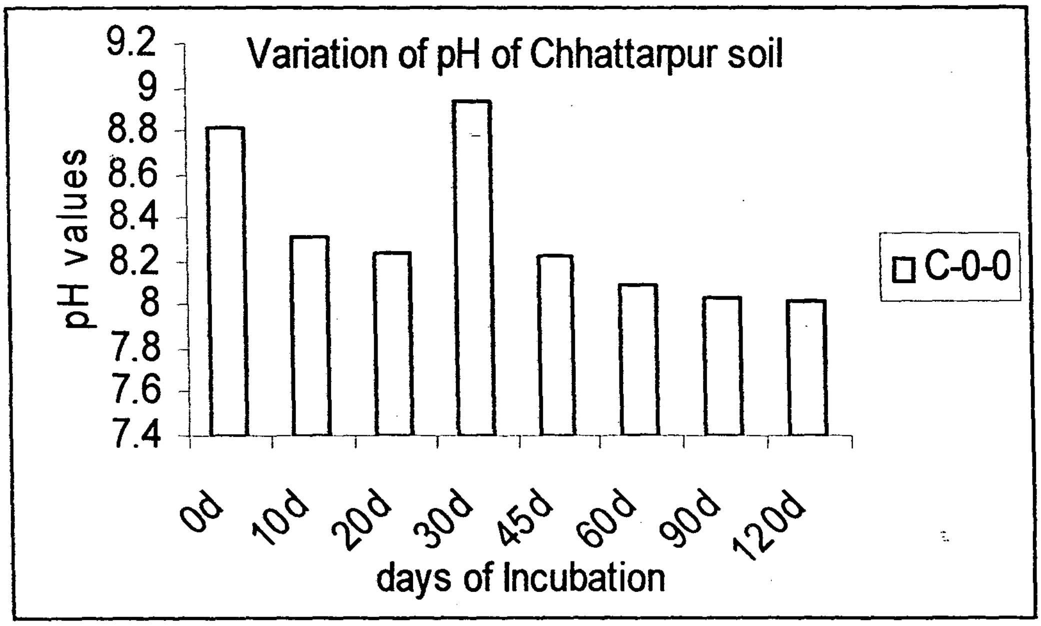


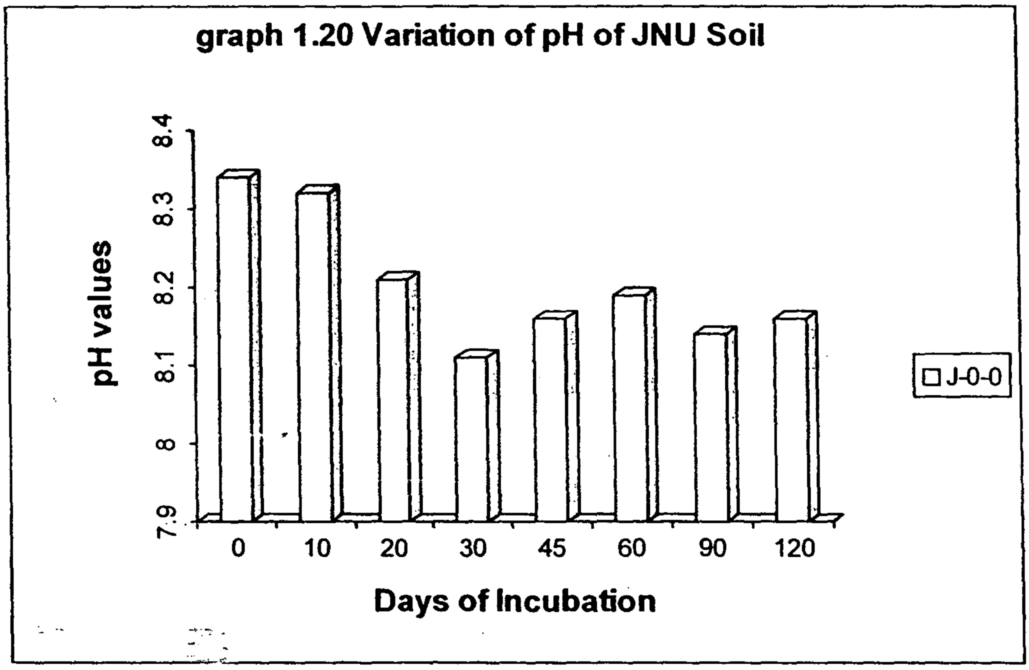
GRAPH 1.17

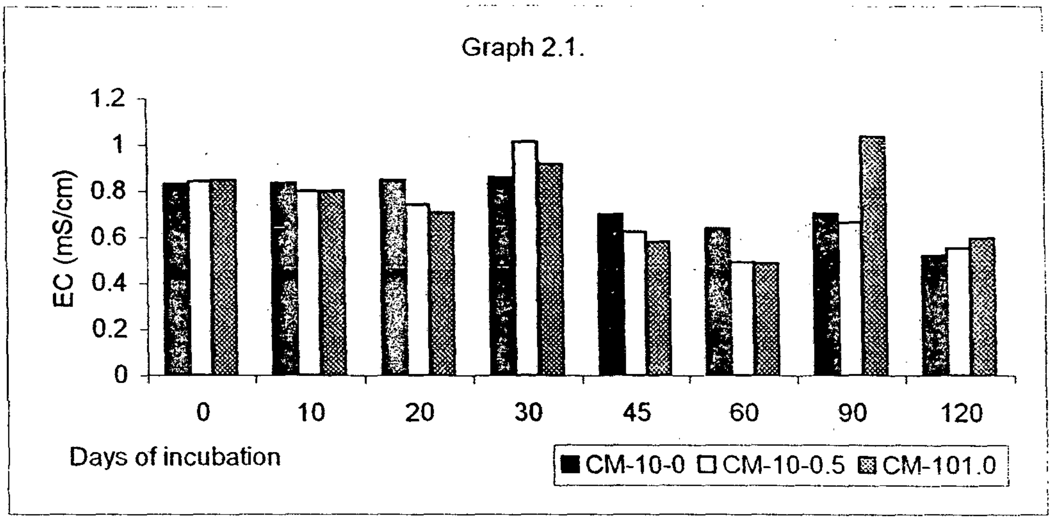


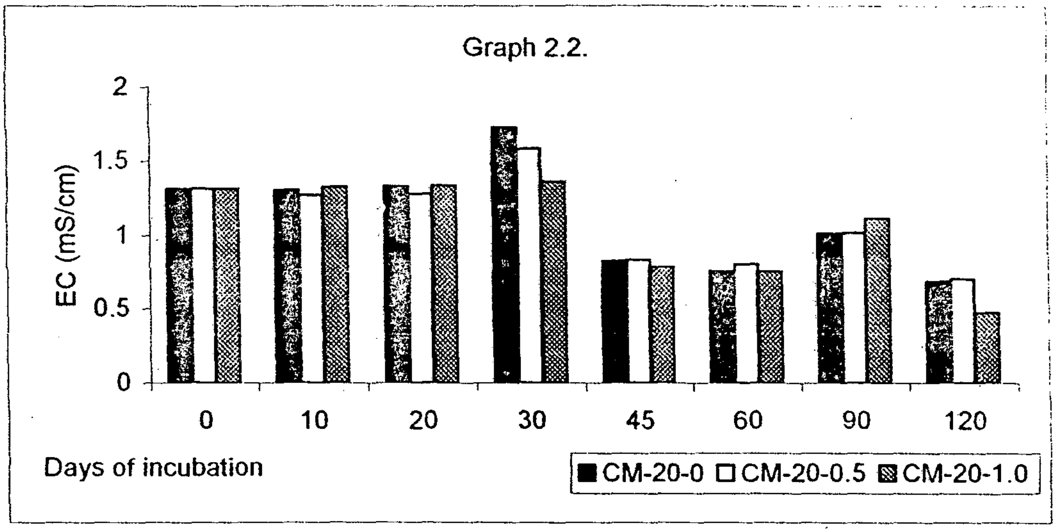
GRAPH 1.18

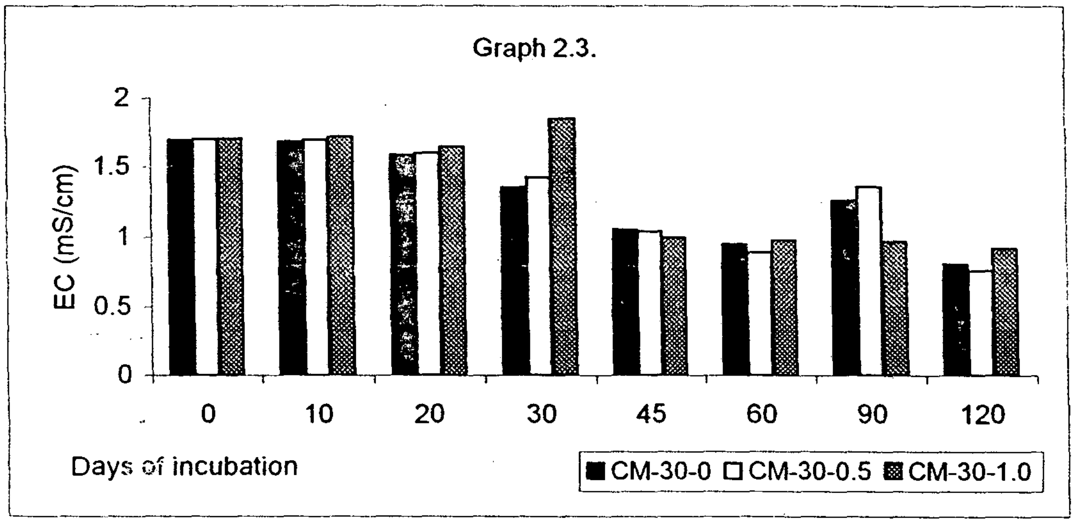


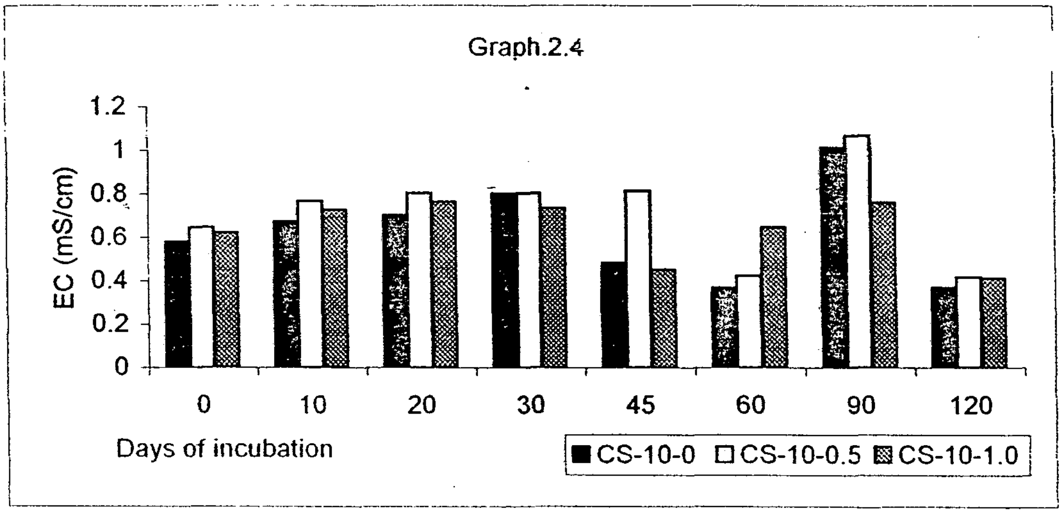

Variation of pH of Chhattarpur soil
pH values
9.2
9
8.8
8.6
8.4
8.2
8
7.8
7.6
7.4
0d
10d
20d
30d
45d
60d
90d
120d
days of Incubation
☐ C-0-0

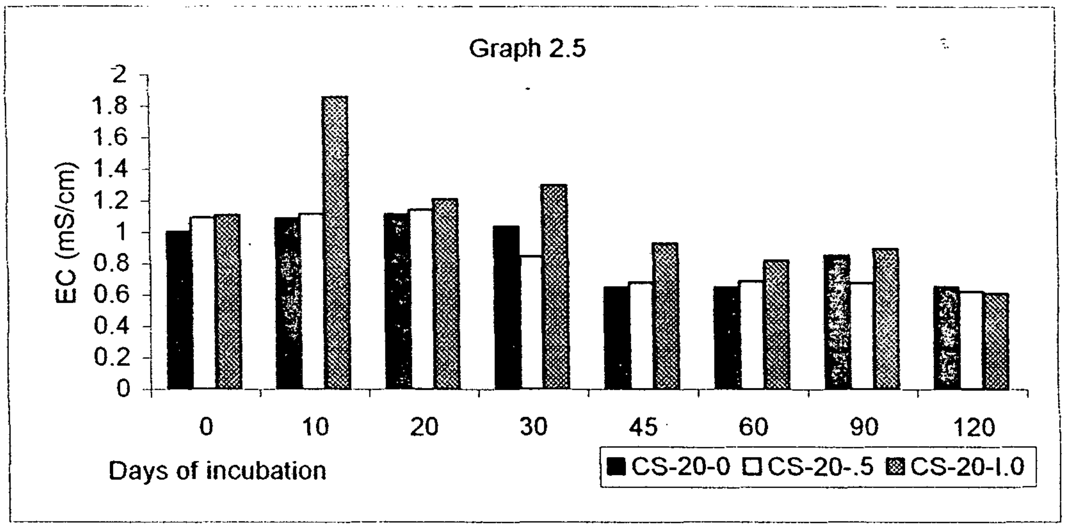

graph 1.20 Variation of pH of JNU Soil
pH values
8.4
8.3
8.2
8.1
8
7.9
0
10
20
30
45
60
90
120
Days of Incubation
☐ J-0-0

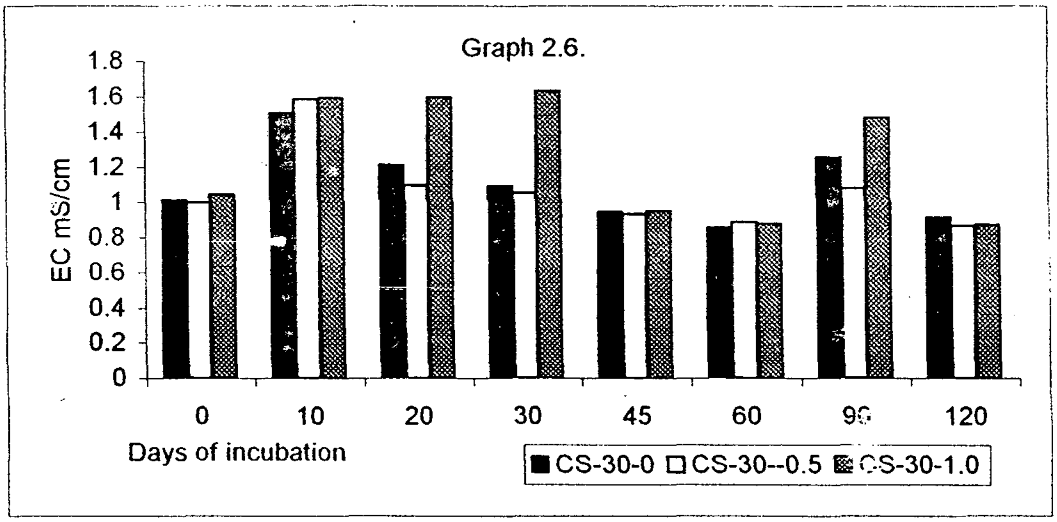

Graph 2.1.


Graph 2.2.

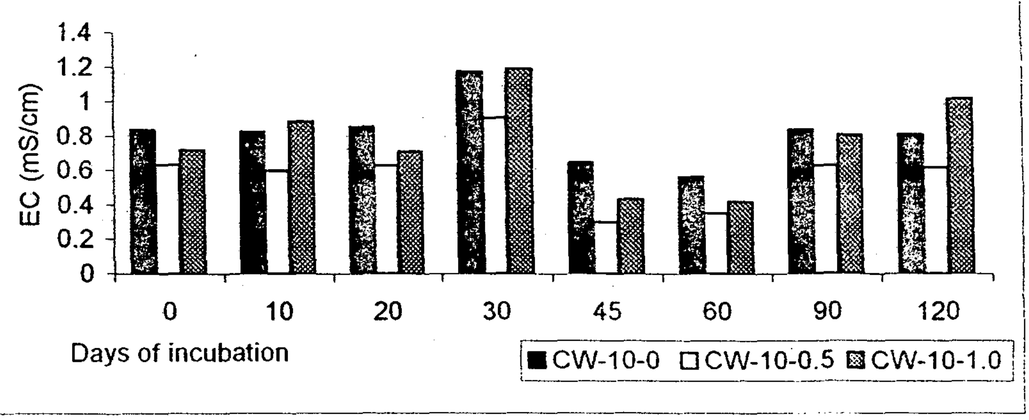

Graph 2.3.


Graph.2.4
EC (mS/cm)
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
45
60
90
120
Days of incubation
■ CS-10-0 □ CS-10-0.5 ▨ CS-10-1.0

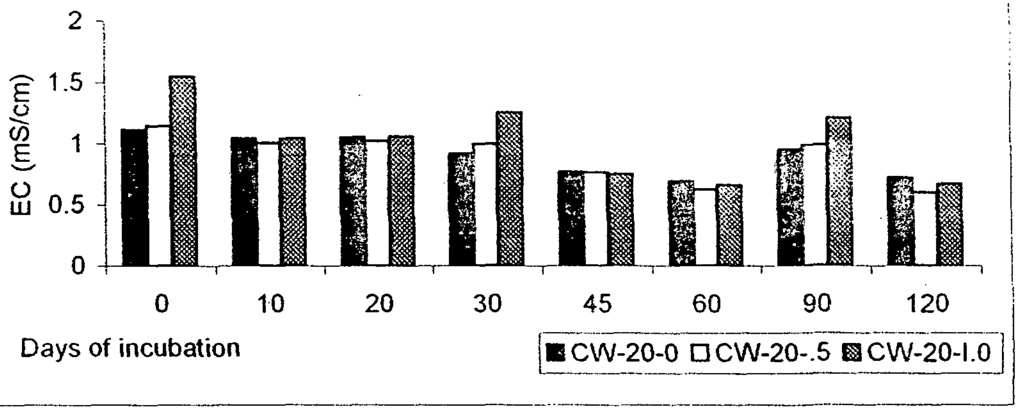

Graph 2.5
EC (mS/cm)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
45
60
90
120
Days of incubation
■ CS-20-0 □ CS-20-.5 ▨ CS-20-l.0


Graph 2.6.
EC mS/cm
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
45
60
90
120
Days of incubation
■ CS-30-0 □ CS-30--0.5 ▨ CS-30-1.0

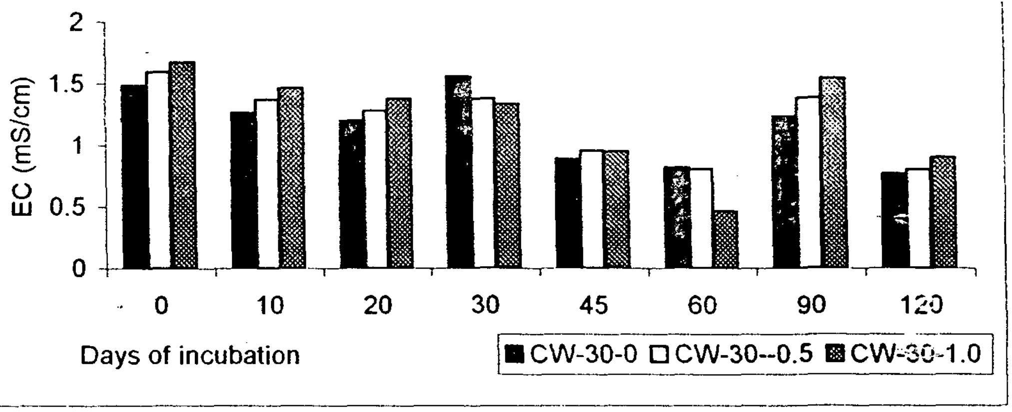
Graph.2..7



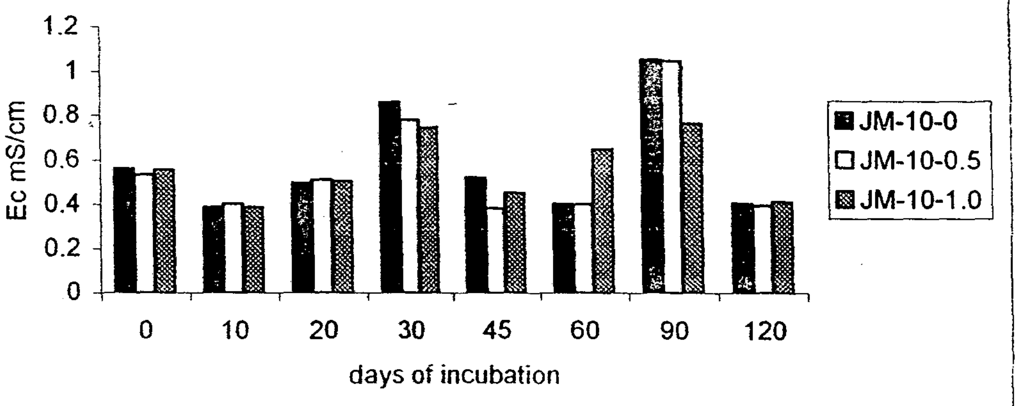
Graph 2.8.



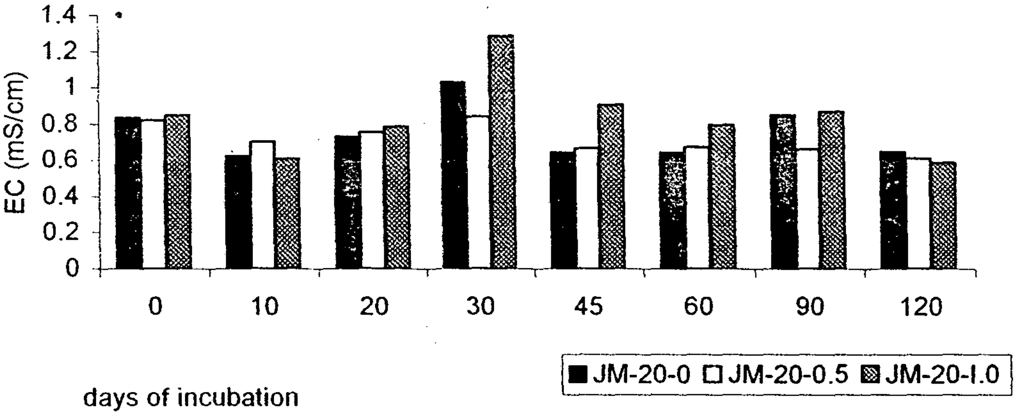
Graph 2.9.



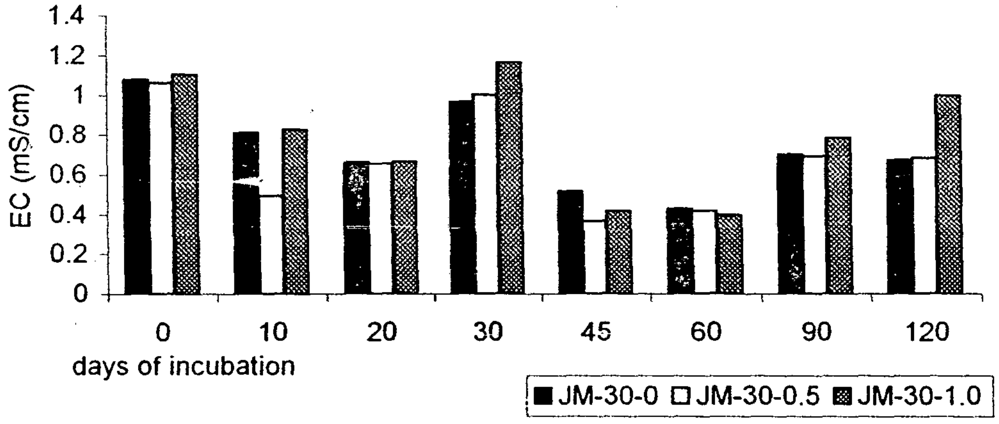
Graph2.10.

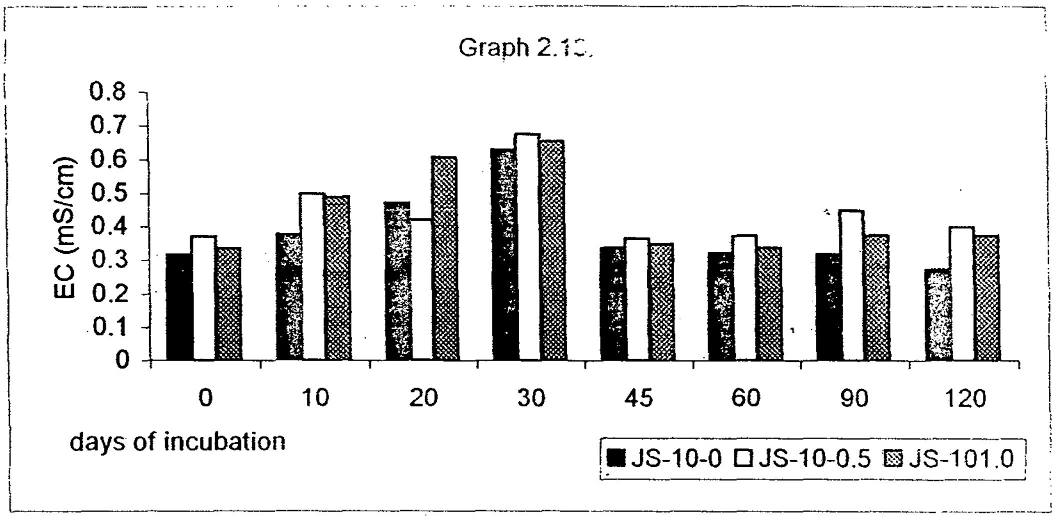


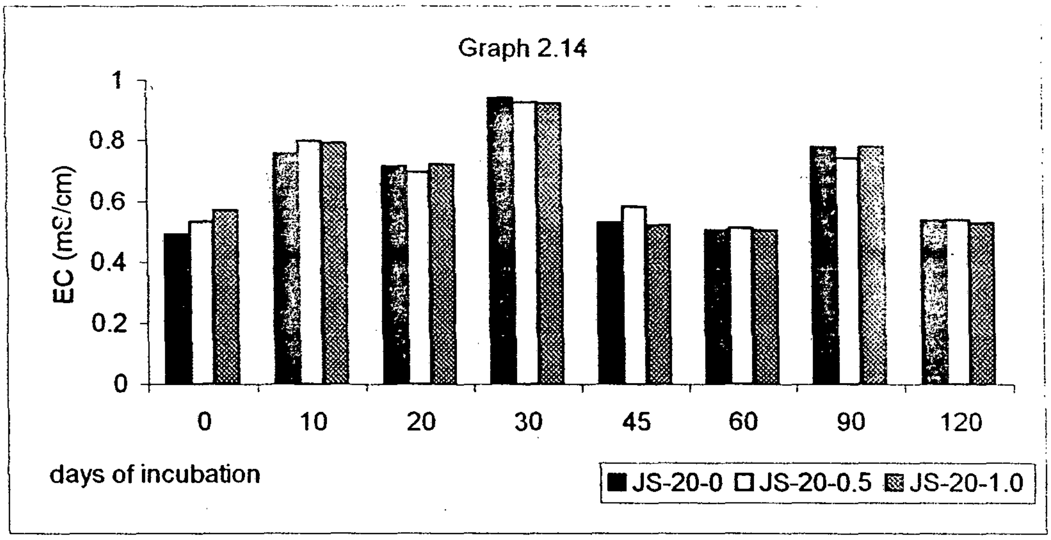
Graph 2.11.

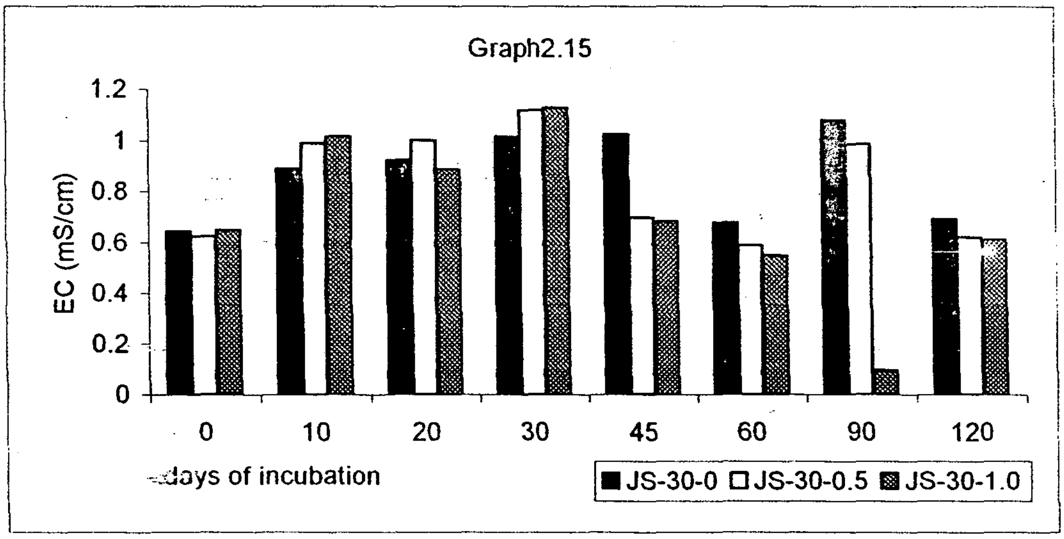


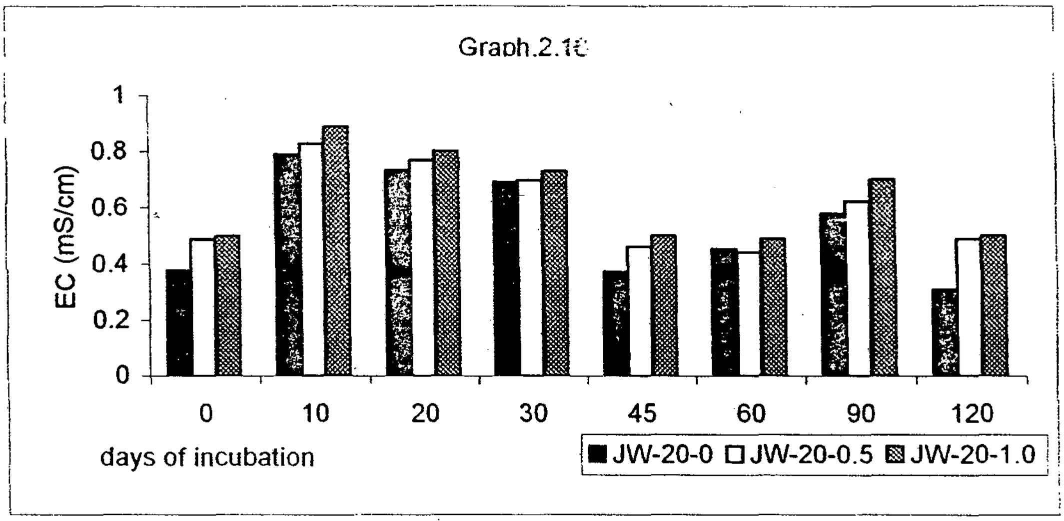
Graph 2.12

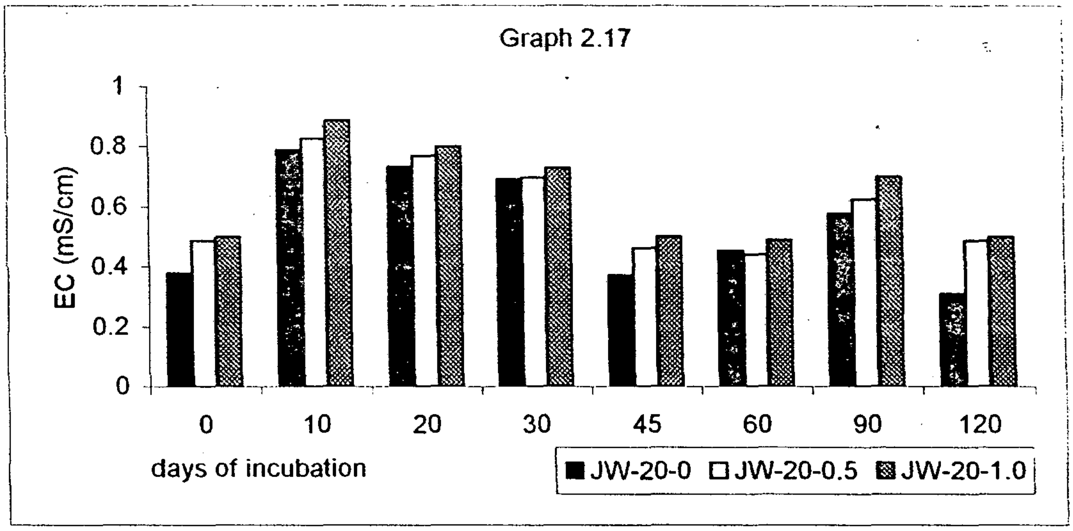


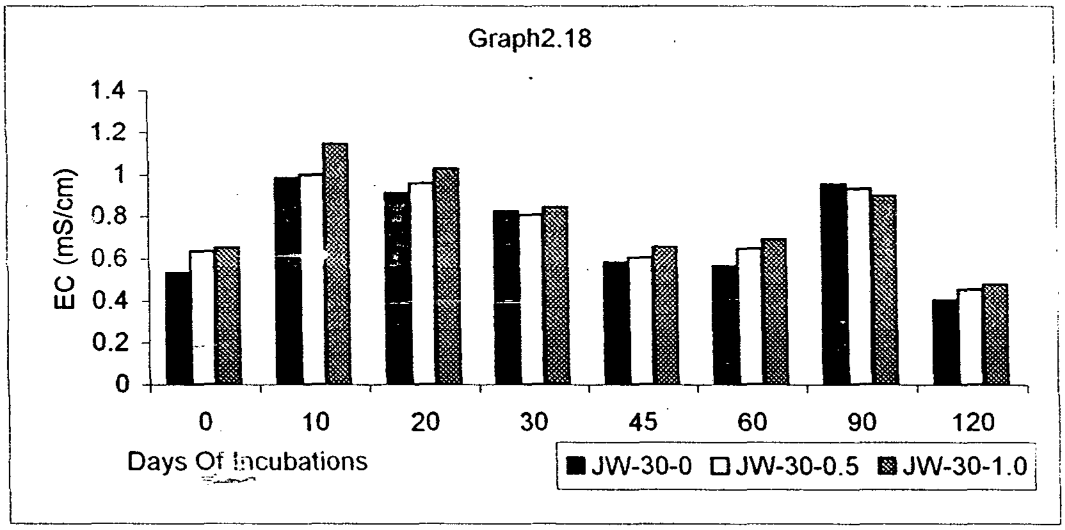

Graph 2.13
EC (mS/cm)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
45
60
90
120
days of incubation
■ JS-10-0 ☐ JS-10-0.5 ▨ JS-101.0

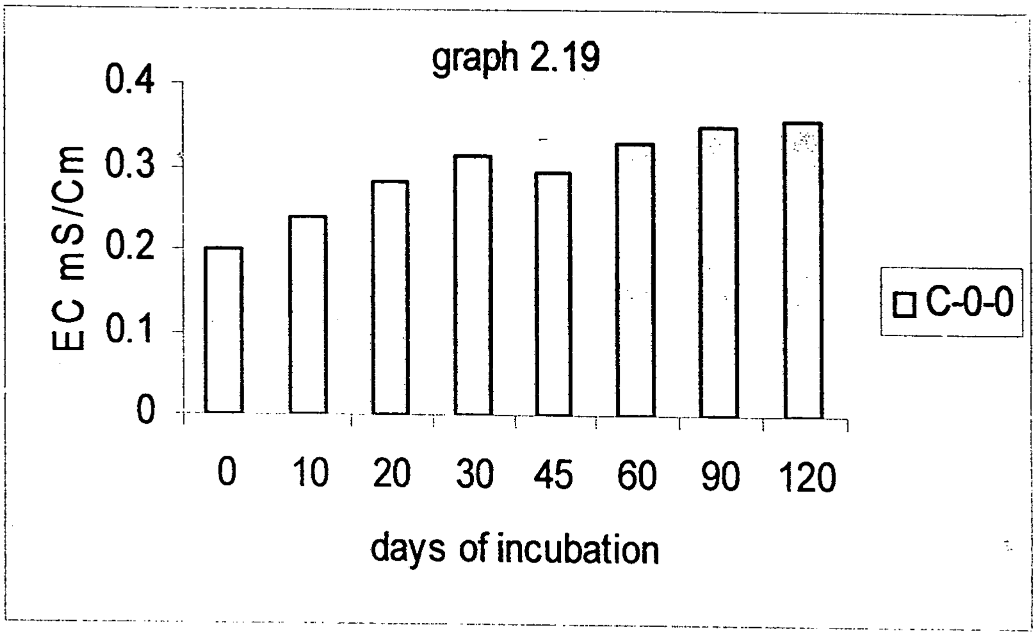

Graph 2.14
EC (mS/cm)
1
0.8
0.6
0.4
0.2
0
0
10
20
30
45
60
90
120
days of incubation
■ JS-20-0 ☐ JS-20-0.5 ▨ JS-20-1.0

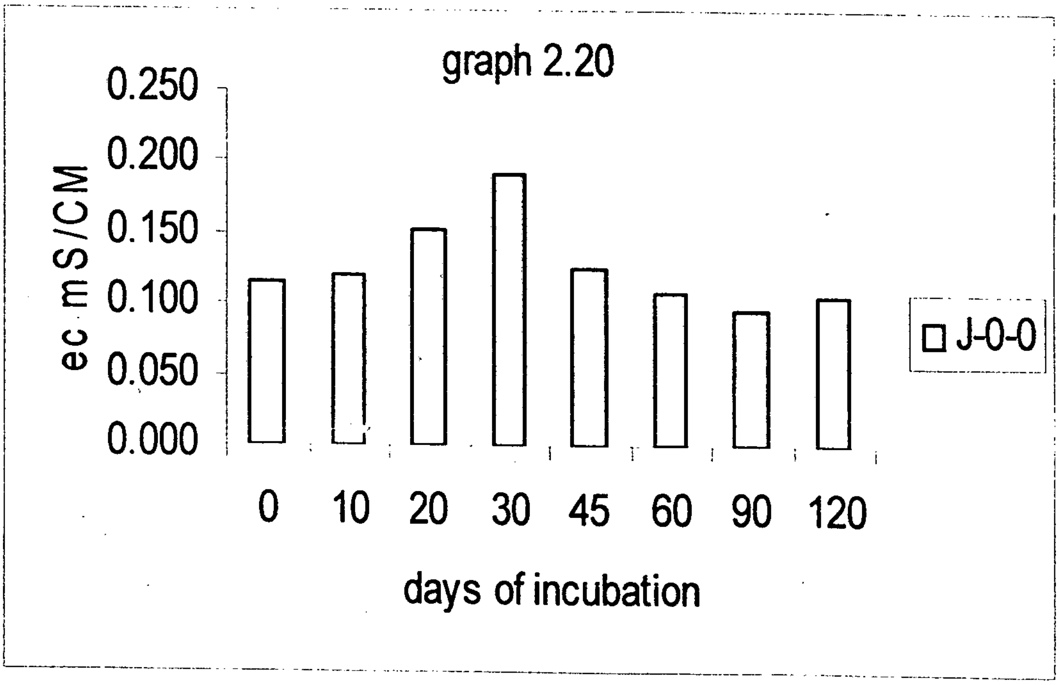

Graph2.15
EC (mS/cm)
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
45
60
90
120
days of incubation
■ JS-30-0 ☐ JS-30-0.5 ▨ JS-30-1.0

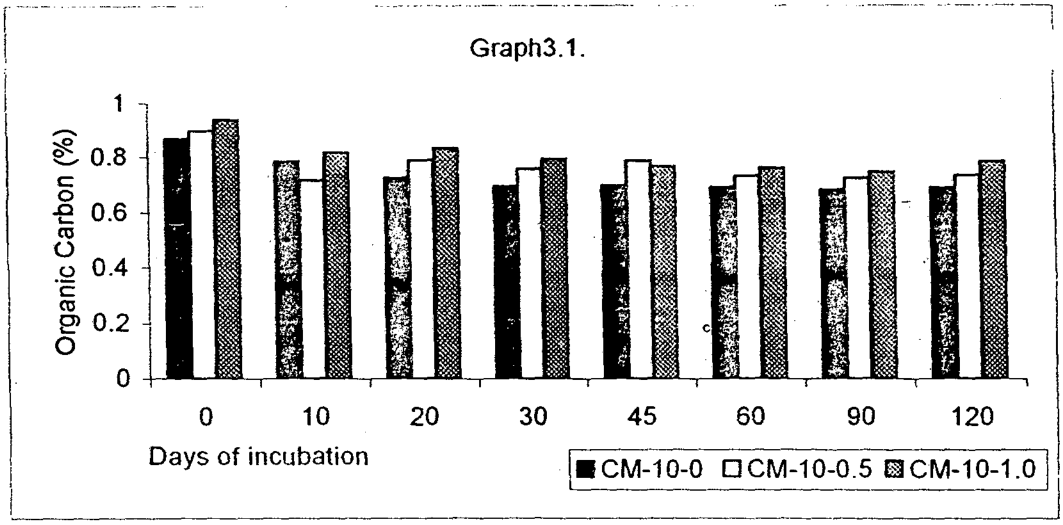

Graph.2.16
EC (mS/cm)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
45
60
90
120
days of incubation
■ JW-20-0
☐ JW-20-0.5
▨ JW-20-1.0

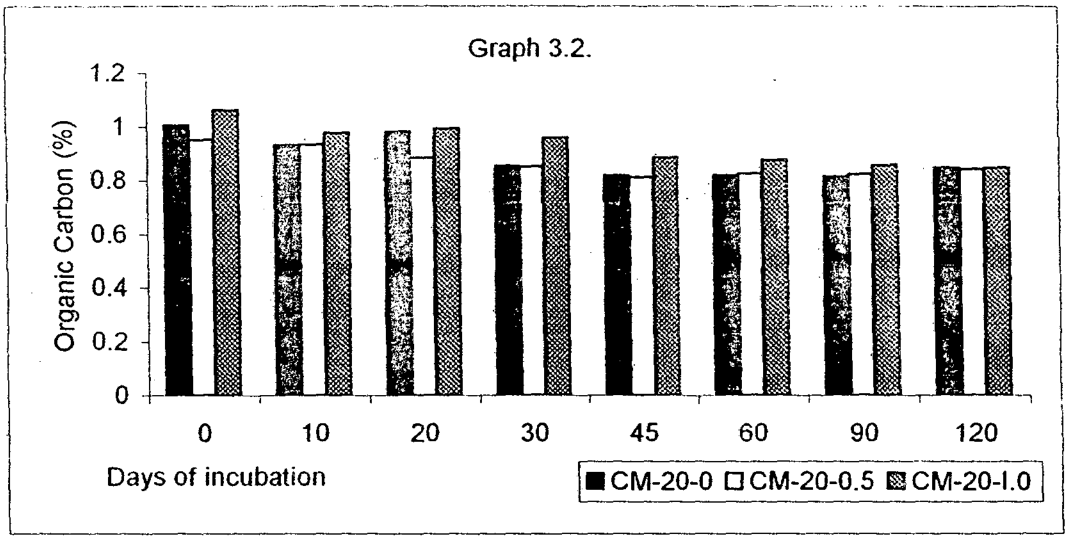

Graph 2.17
EC (mS/cm)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
45
60
90
120
days of incubation
■ JW-20-0
☐ JW-20-0.5
▨ JW-20-1.0

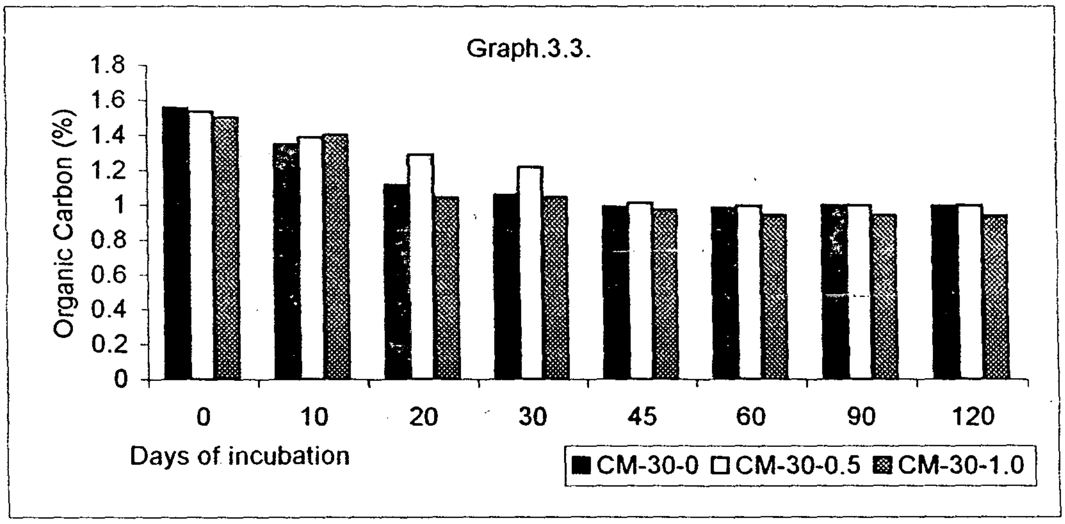

Graph2.18
EC (mS/cm)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
10
20
30
45
60
90
120
Days Of Incubations
■ JW-30-0
☐ JW-30-0.5
▨ JW-30-1.0

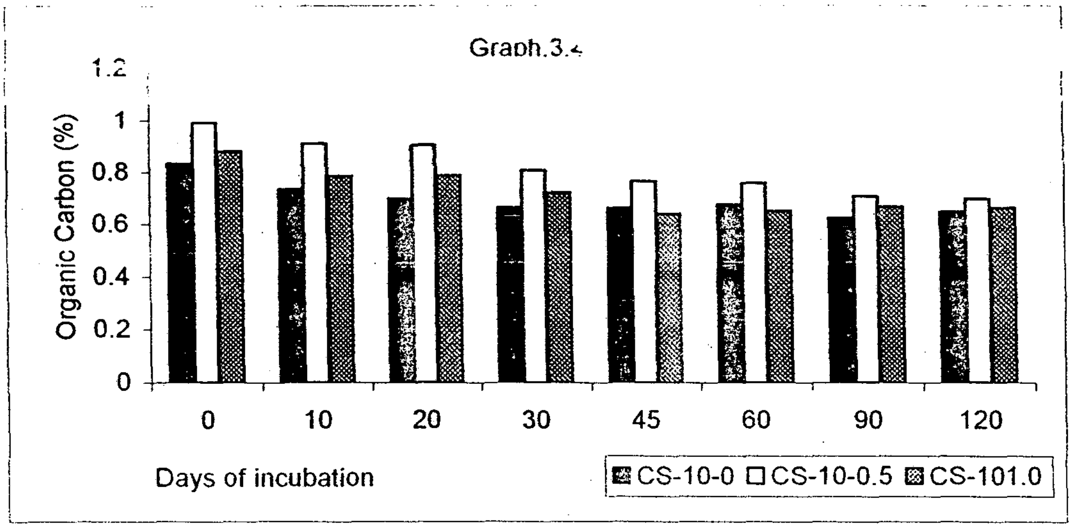

graph 2.19
EC mS/Cm
0.4
0.3
0.2
0.1
0
0
10
20
30
45
60
90
120
days of incubation
☐ C-0-0

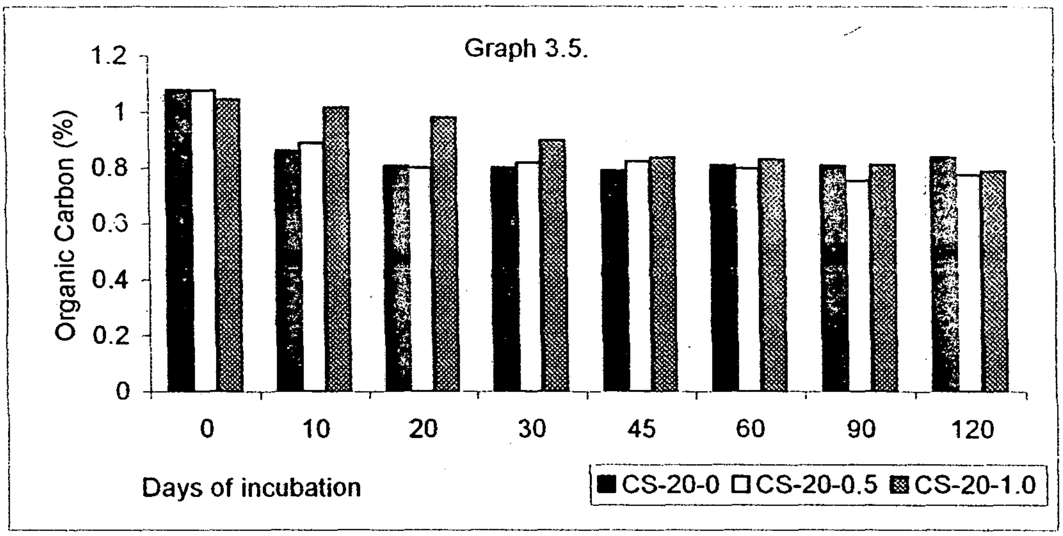

graph 2.20
ec mS/CM
0.250
0.200
0.150
0.100
0.050
0.000
0
10
20
30
45
60
90
120
days of incubation
☐ J-0-0

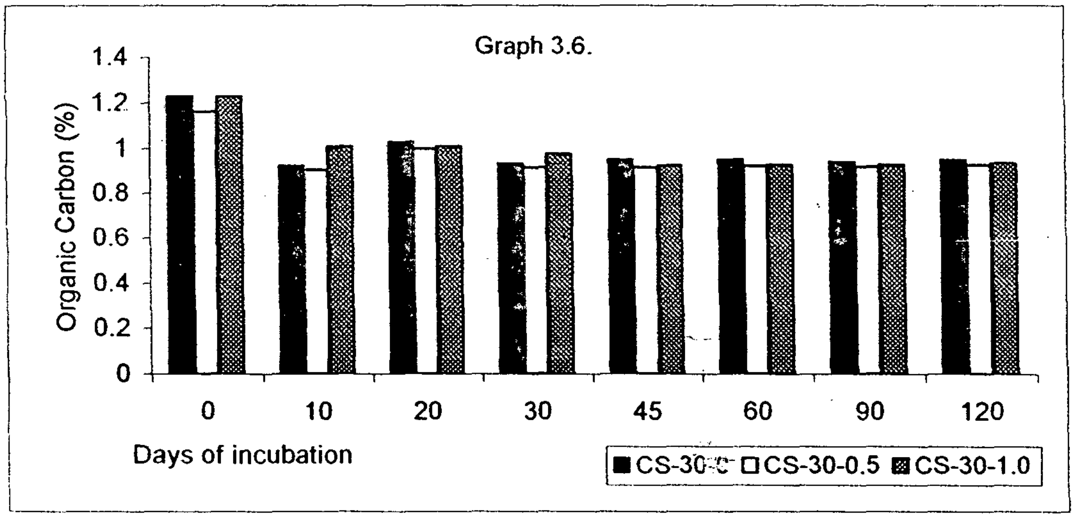

Graph3.1.
Organic Carbon (%)
1
0.8
0.6
0.4
0.2
0
0
10
20
30
45
60
90
120
Days of incubation
■ CM-10-0 □ CM-10-0.5 ▨ CM-10-1.0

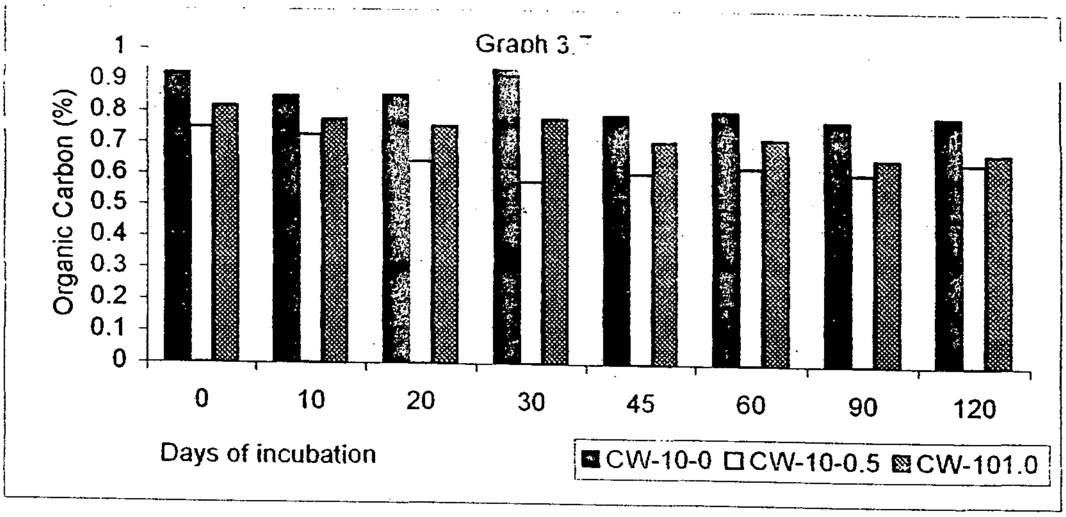

Graph 3.2.
Organic Carbon (%)
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
45
60
90
120
Days of incubation
■ CM-20-0 □ CM-20-0.5 ▨ CM-20-l.0


Graph.3.3.
Organic Carbon (%)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
45
60
90
120
Days of incubation
■ CM-30-0 □ CM-30-0.5 ▨ CM-30-1.0

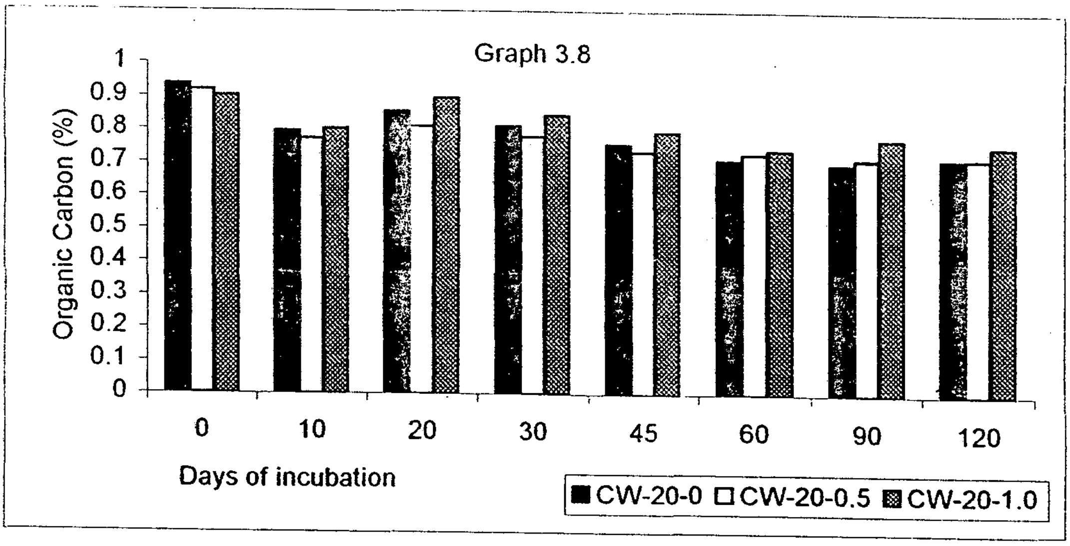

Graph.3.4


Graph 3.5.

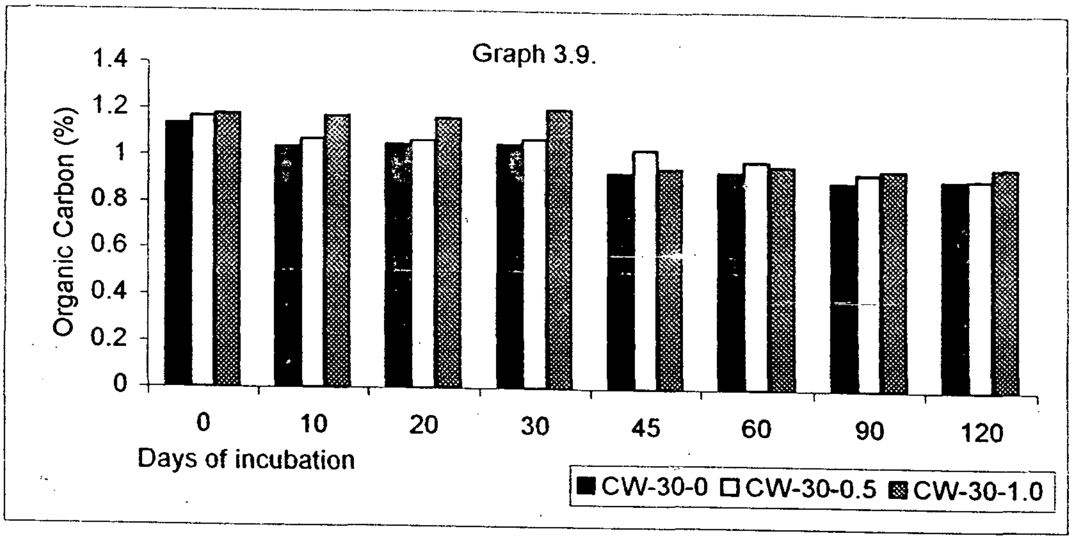

Graph 3.6.



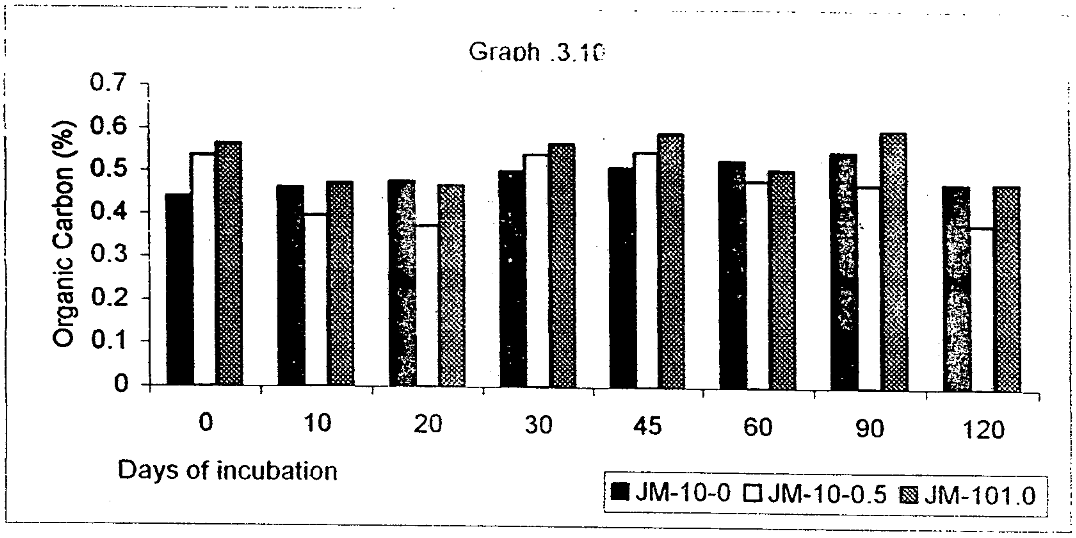
Graph 3.7

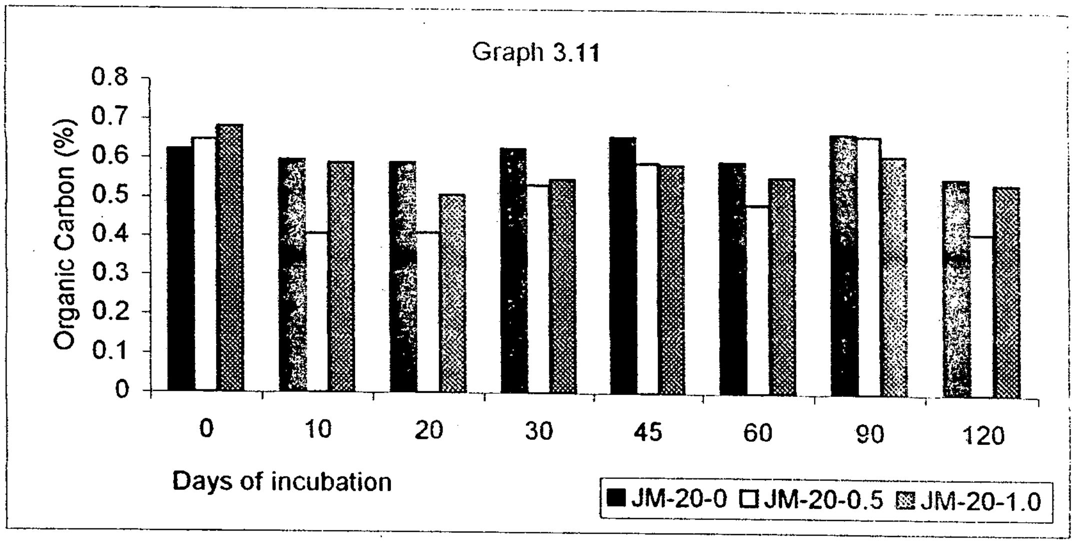


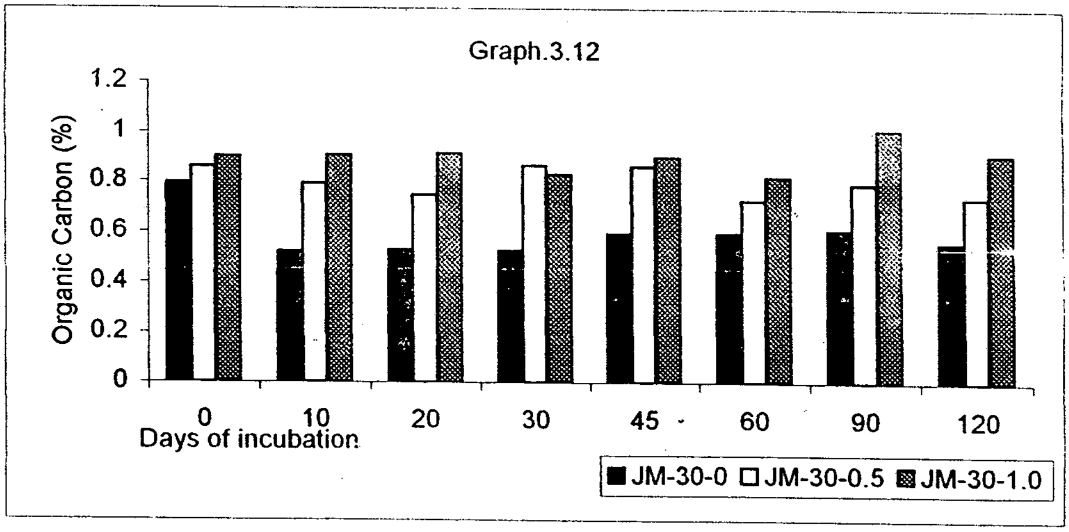
Graph 3.8

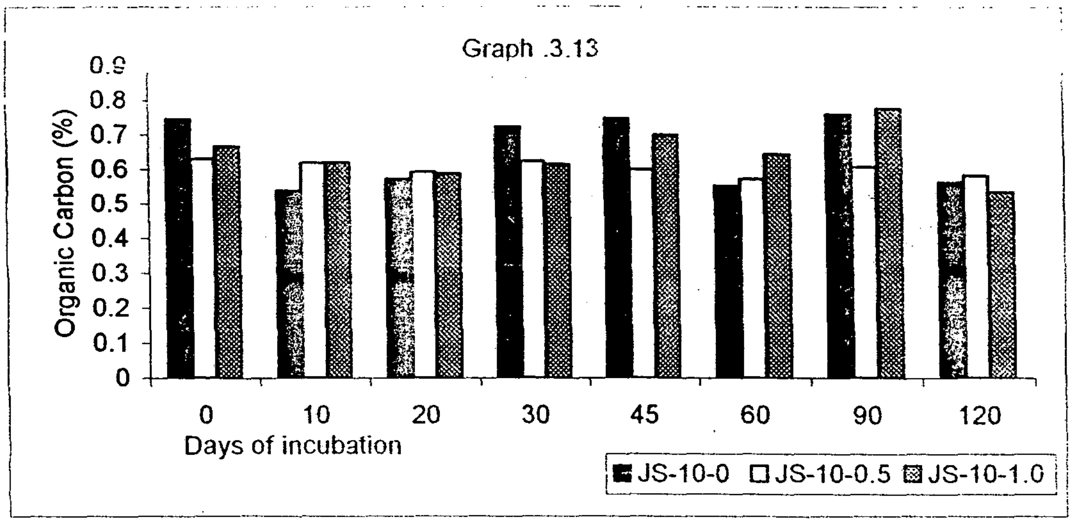


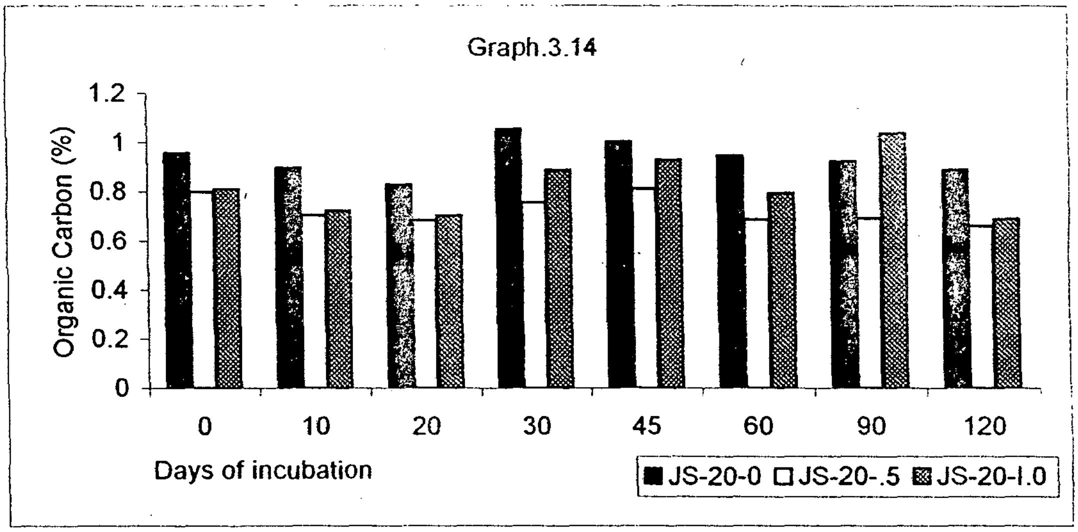
Graph 3.9.

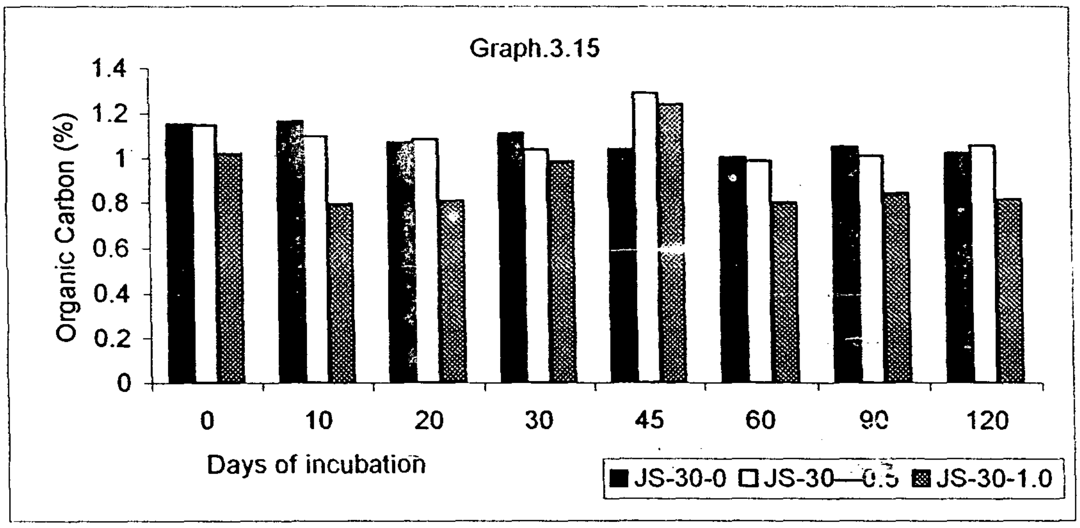

Graph .3.10
Organic Carbon (%)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
45
60
90
120
Days of incubation
■ JM-10-0 □ JM-10-0.5 ▨ JM-101.0

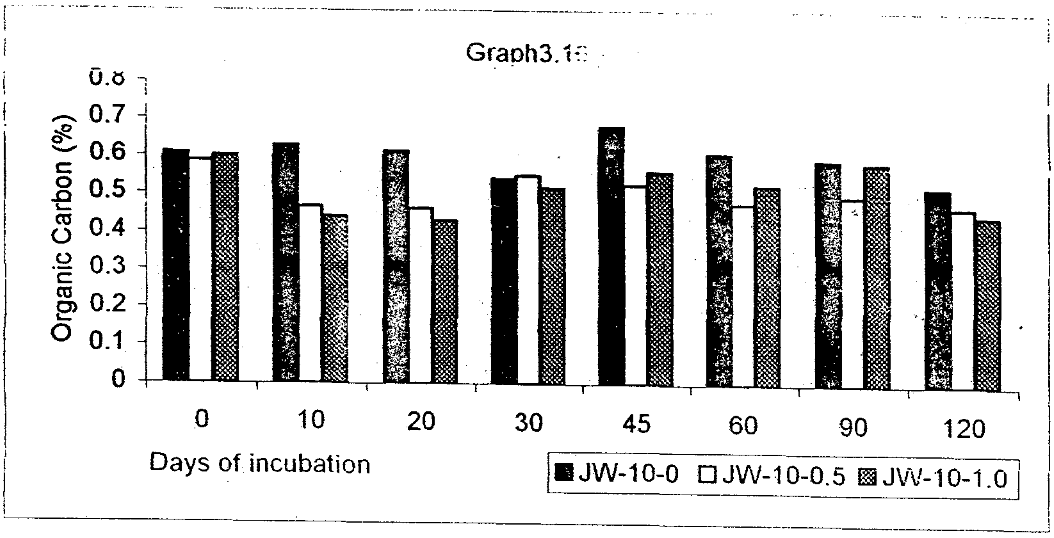

Graph 3.11
Organic Carbon (%)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
45
60
90
120
Days of incubation
■ JM-20-0 □ JM-20-0.5 ▨ JM-20-1.0

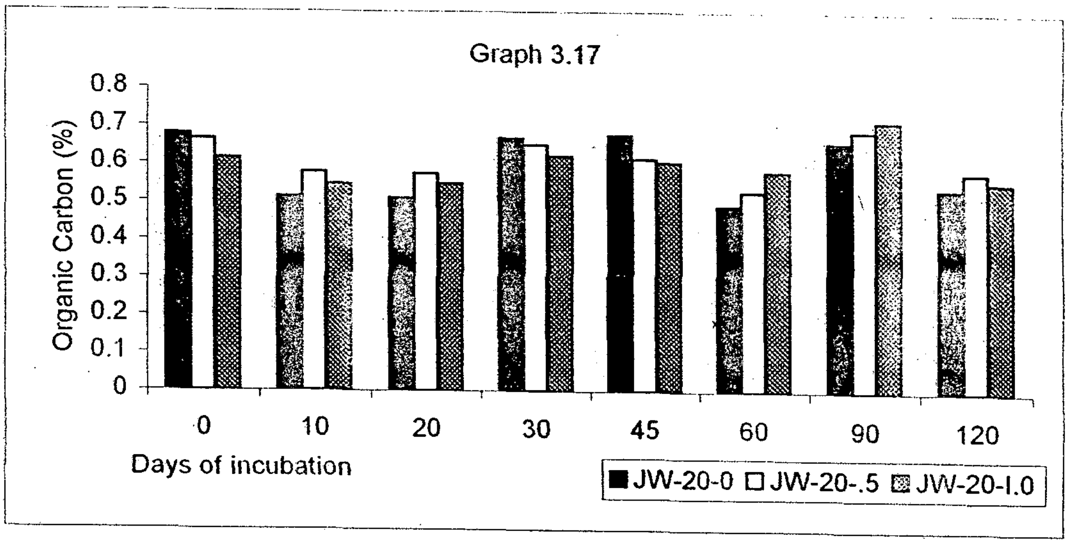

Graph.3.12
Organic Carbon (%)
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
45
60
90
120
Days of incubation
■ JM-30-0 □ JM-30-0.5 ▨ JM-30-1.0

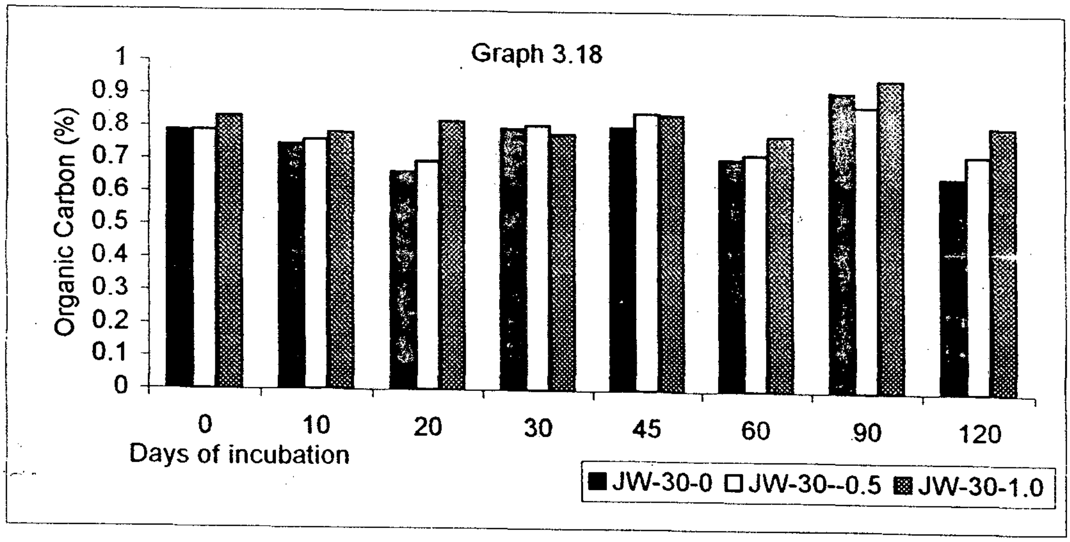

Graph .3.13
Organic Carbon (%)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
45
60
90
120
Days of incubation
■ JS-10-0
□ JS-10-0.5
▨ JS-10-1.0

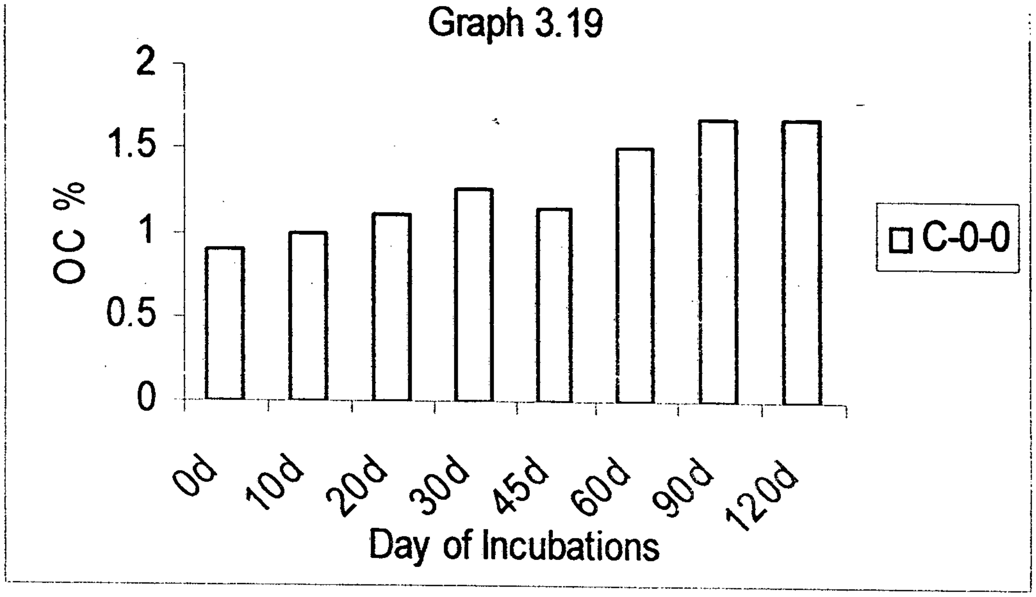

Graph.3.14
Organic Carbon (%)
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
45
60
90
120
Days of incubation
■ JS-20-0
□ JS-20-.5
▨ JS-20-1.0

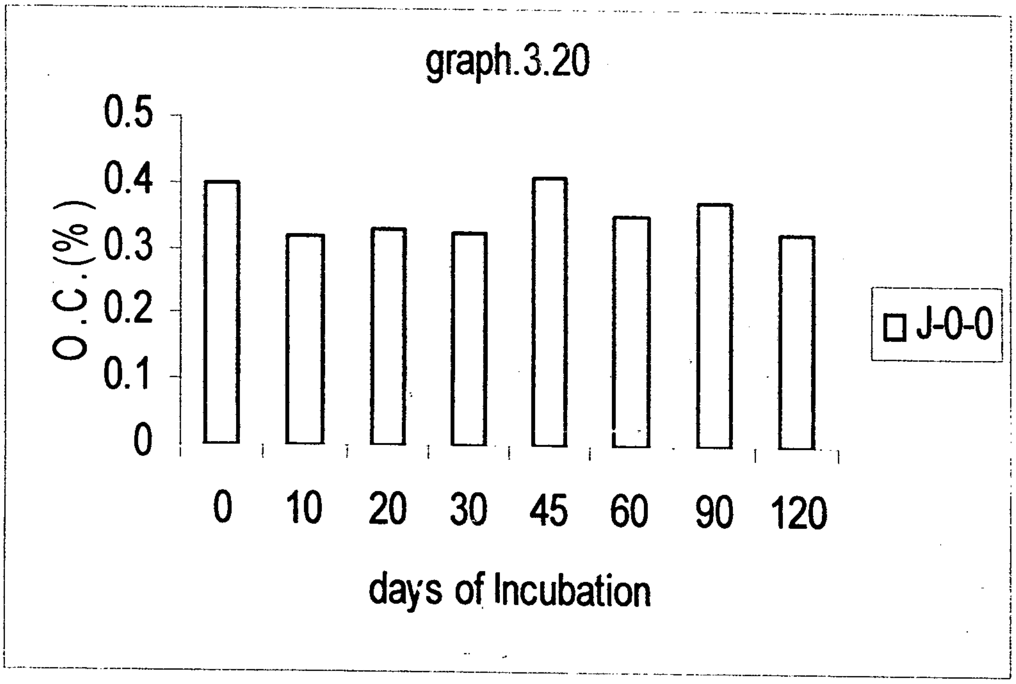

Graph.3.15
Organic Carbon (%)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
45
60
90
120
Days of incubation
■ JS-30-0
□ JS-30—0.5
▨ JS-30-1.0

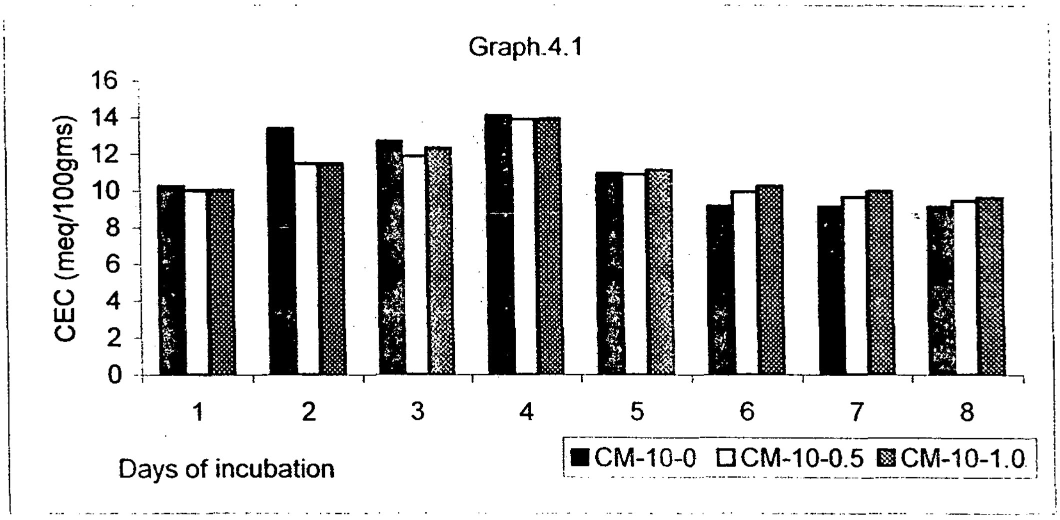

Graph3.16

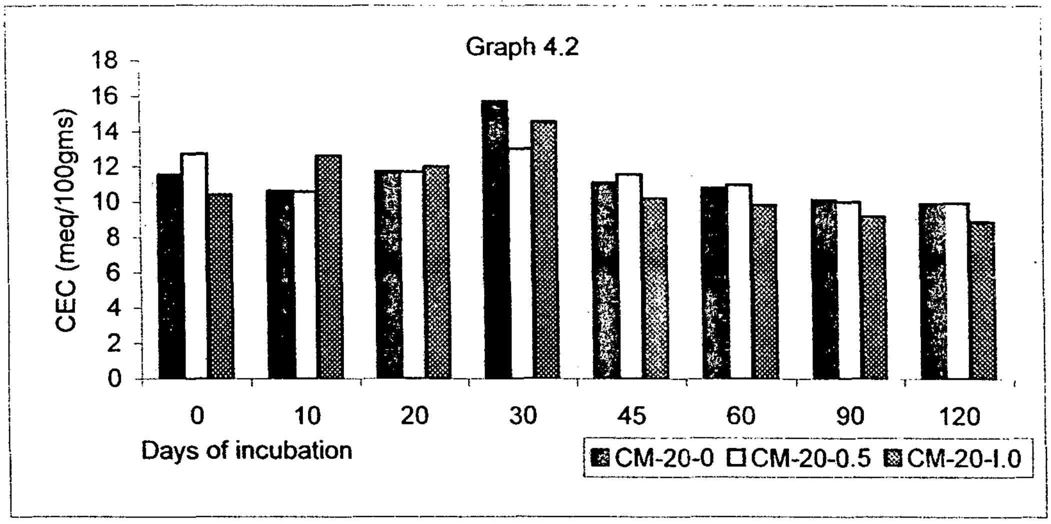

Graph 3.17

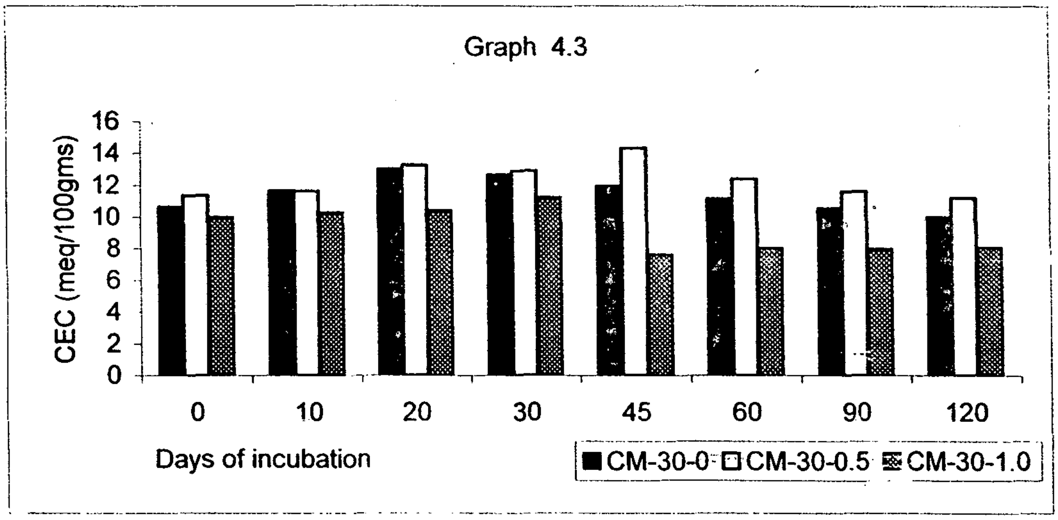

Graph 3.18

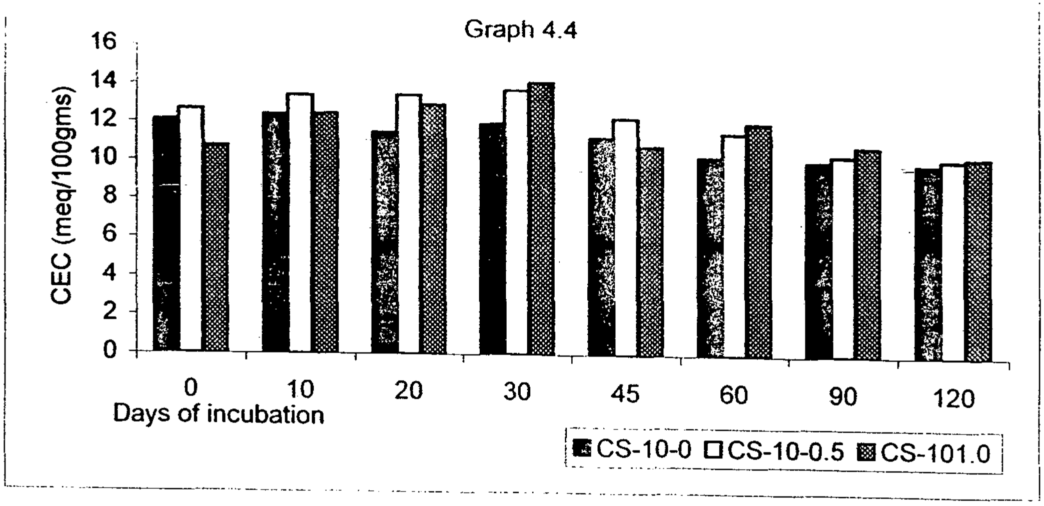

Graph 3.19
2
1.5
1
0.5
0
OC %
0d
10d
20d
30d
45d
60d
90d
120d
Day of Incubations
□ C-0-0

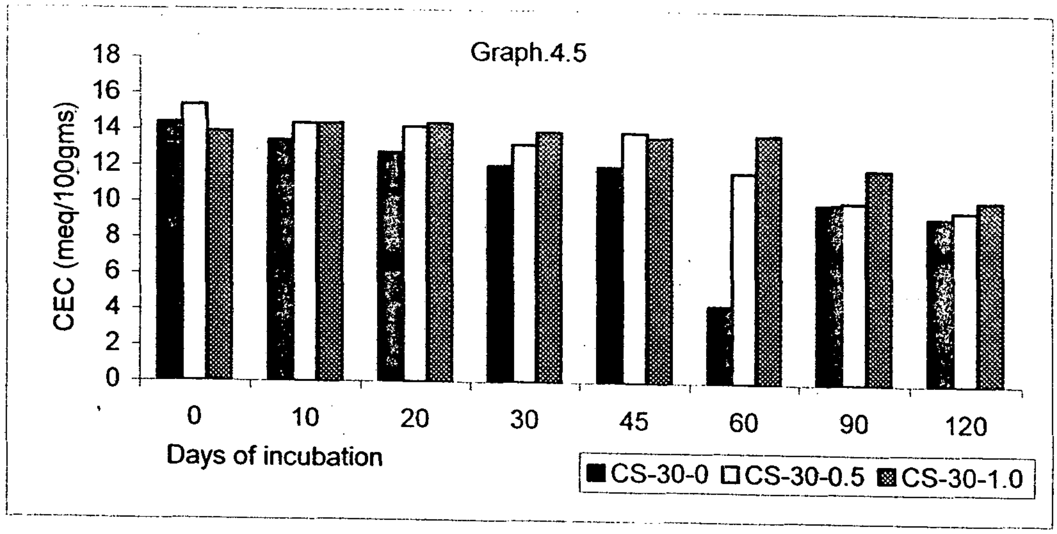

graph.3.20
0.5
0.4
0.3
0.2
0.1
0
O.C.(%)
0
10
20
30
45
60
90
120
days of Incubation
□ J-0-0

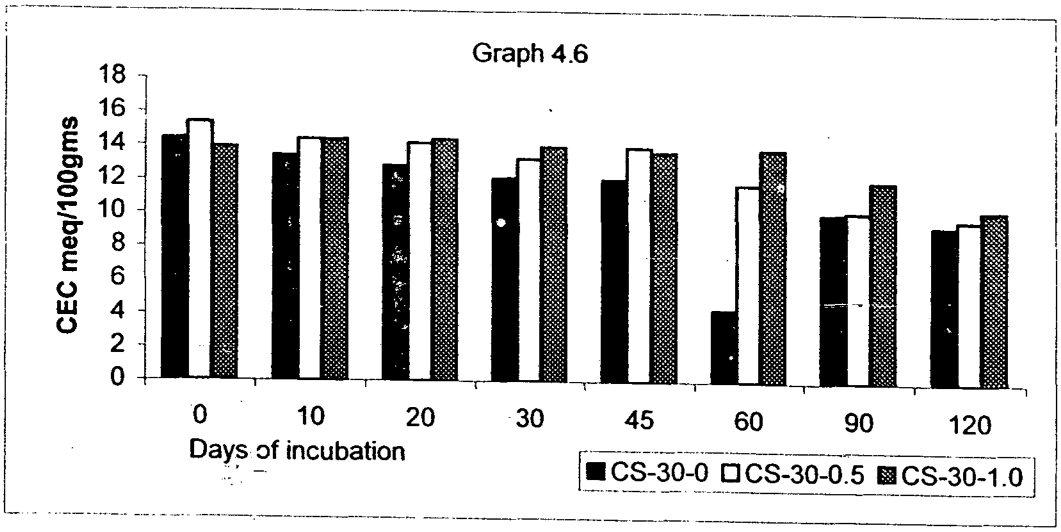

Graph.4.1
CEC (meq/100gms)
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
Days of incubation
■CM-10-0 □CM-10-0.5 ▨CM-10-1.0

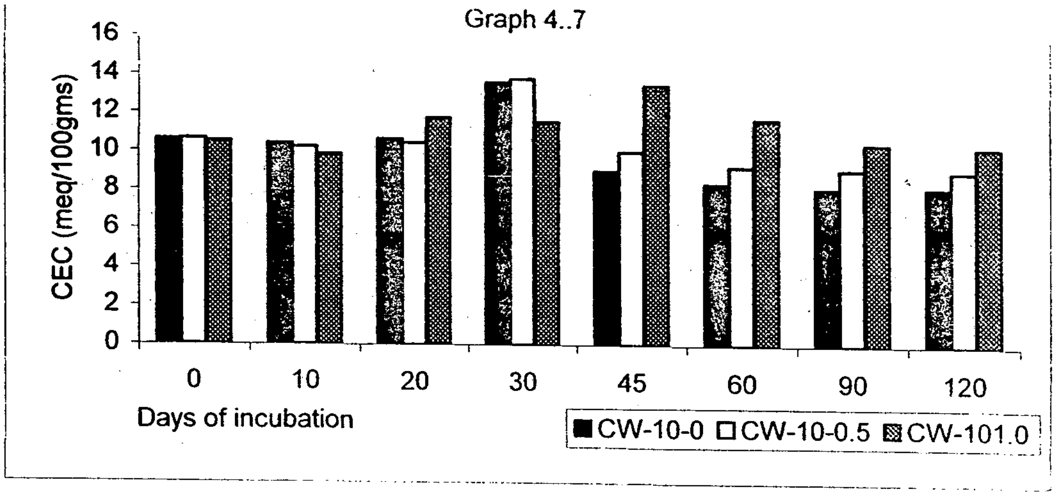

Graph 4.2
CEC (meq/100gms)
18
16
14
12
10
8
6
4
2
0
0
10
20
30
45
60
90
120
Days of incubation
▨CM-20-0 □CM-20-0.5 ▨CM-20-1.0

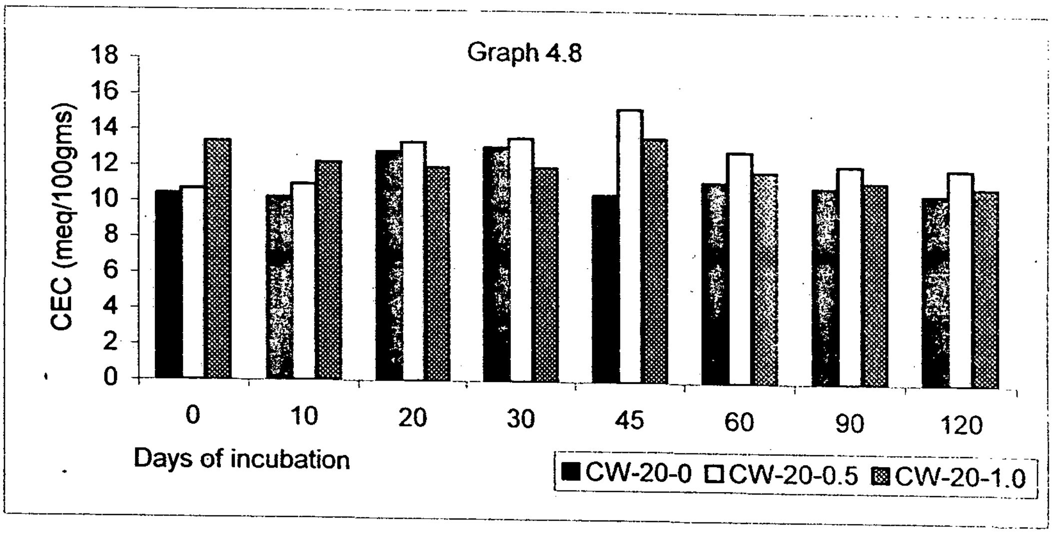

Graph 4.3
CEC (meq/100gms)
16
14
12
10
8
6
4
2
0
0
10
20
30
45
60
90
120
Days of incubation
■CM-30-0 □CM-30-0.5 ▨CM-30-1.0

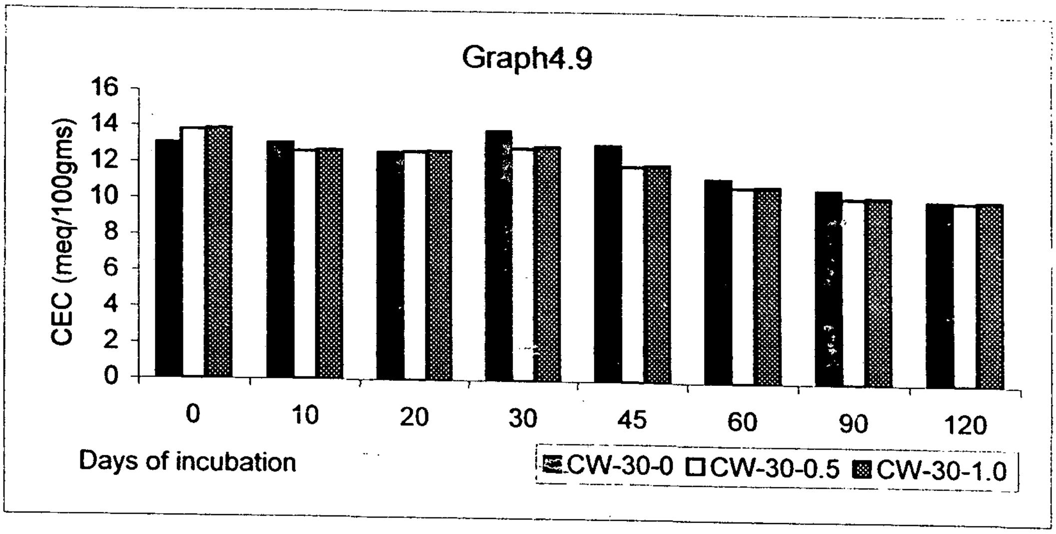

Graph 4.4
CEC (meq/100gms)
16
14
12
10
8
6
4
2
0
0
10
20
30
45
60
90
120
Days of incubation
CS-10-0
CS-10-0.5
CS-101.0

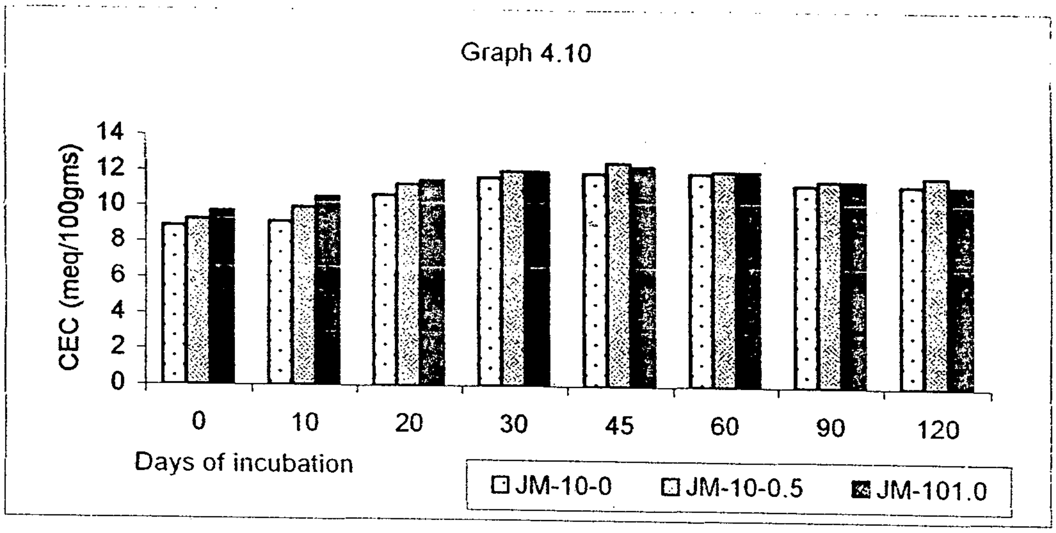

Graph.4.5
CEC (meq/100gms)
18
16
14
12
10
8
6
4
2
0
0
10
20
30
45
60
90
120
Days of incubation
CS-30-0
CS-30-0.5
CS-30-1.0


Graph 4.6
CEC meq/100gms
18
16
14
12
10
8
6
4
2
0
0
10
20
30
45
60
90
120
Days of incubation
CS-30-0
CS-30-0.5
CS-30-1.0

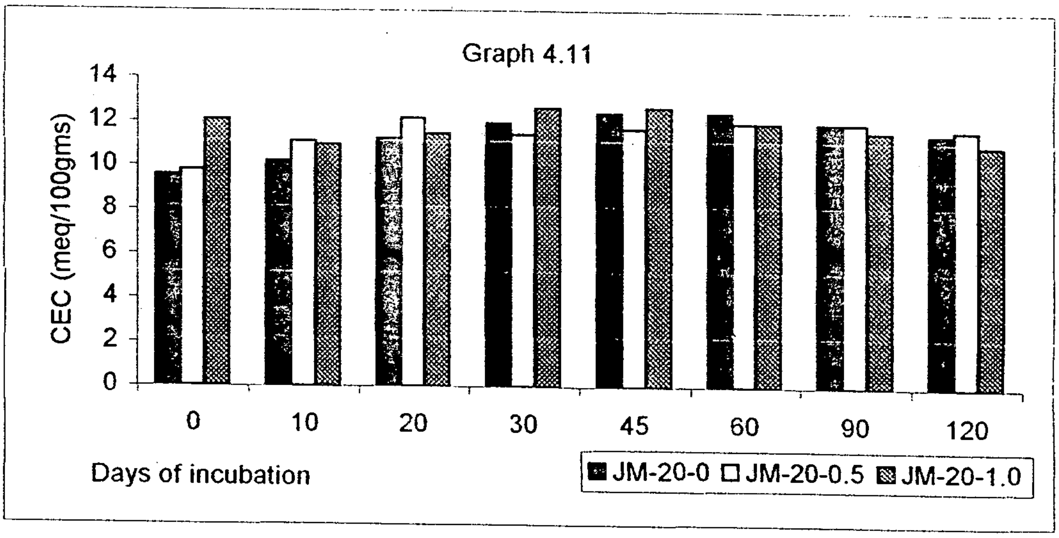

Graph 4..7
CEC (meq/100gms)
16
14
12
10
8
6
4
2
0
0
10
20
30
45
60
90
120
Days of incubation
■CW-10-0 □CW-10-0.5 ▨CW-101.0


Graph 4.8
CEC (meq/100gms)
18
16
14
12
10
8
6
4
2
0
0
10
20
30
45
60
90
120
Days of incubation
■CW-20-0 □CW-20-0.5 ▨CW-20-1.0

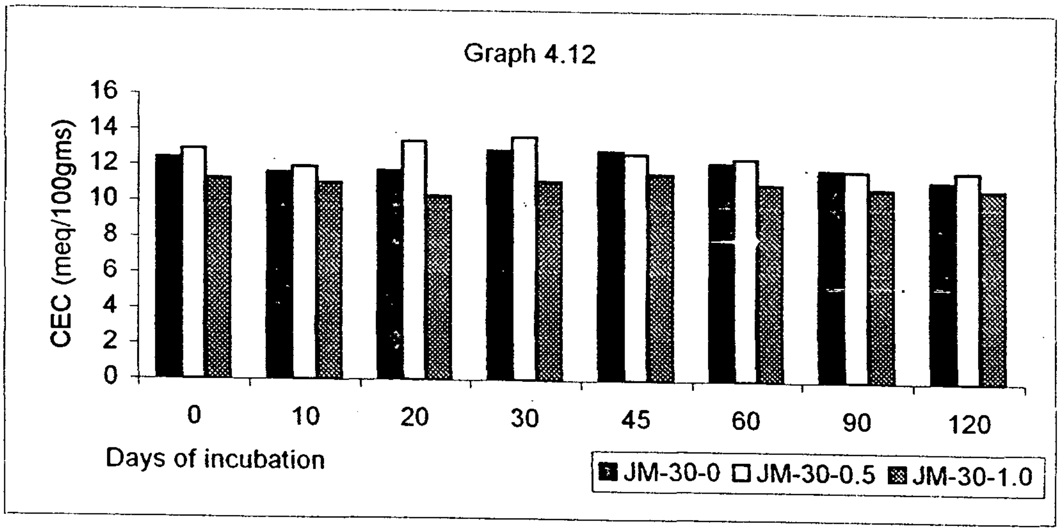

Graph4.9
CEC (meq/100gms)
16
14
12
10
8
6
4
2
0
0
10
20
30
45
60
90
120
Days of incubation
▨CW-30-0 □CW-30-0.5 ■CW-30-1.0



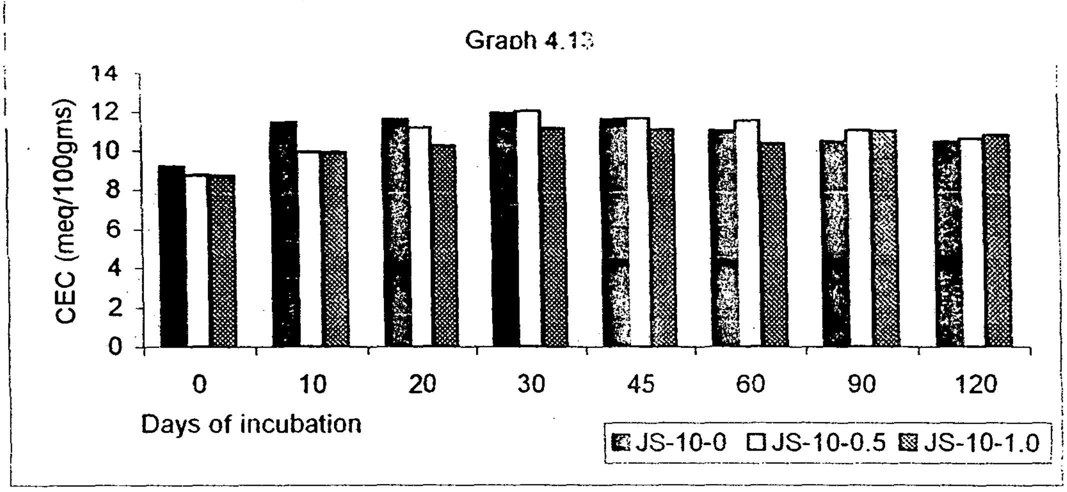
Graph 4.10



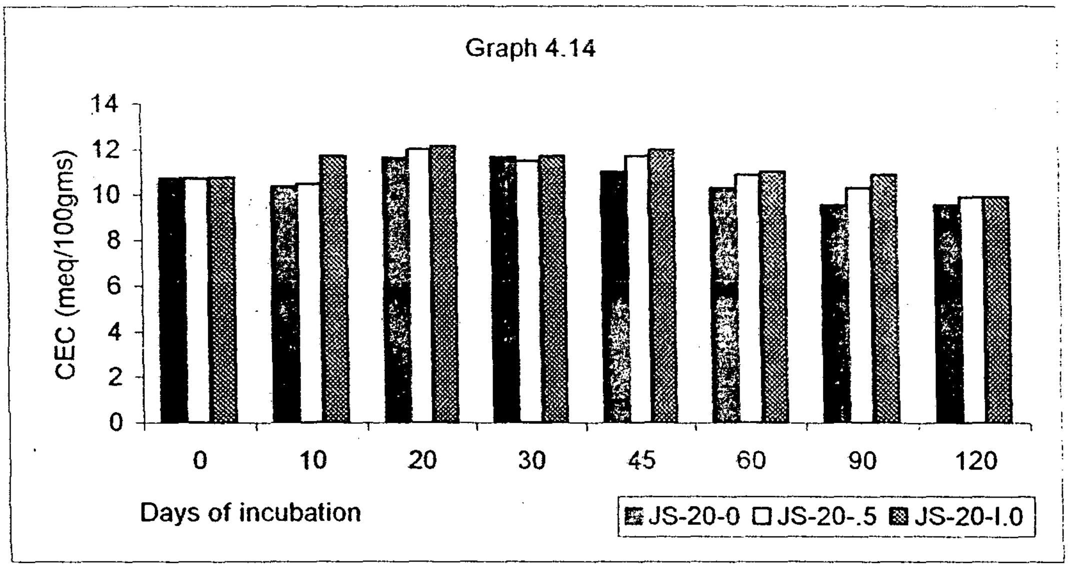
Graph 4.11



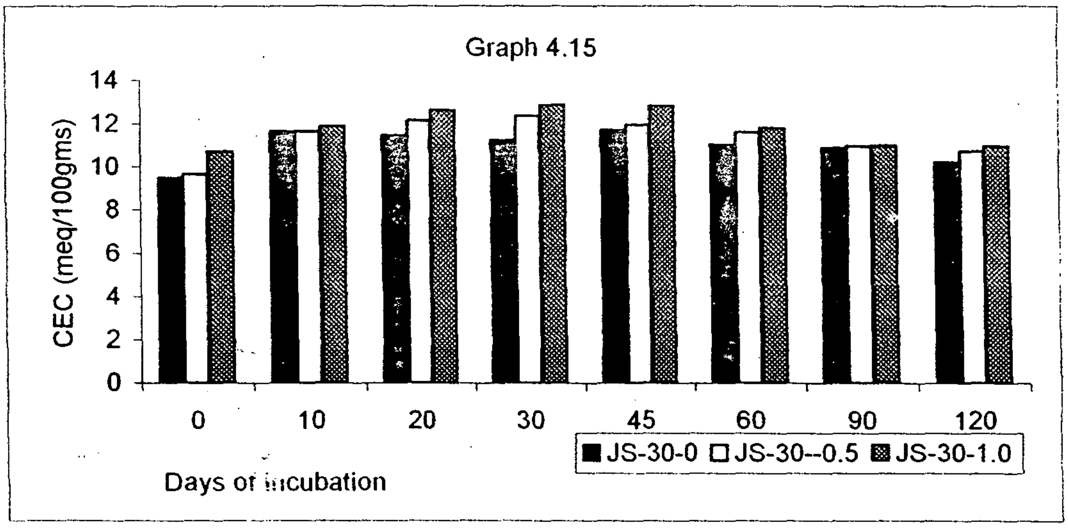
Graph 4.12



Graph 4.13

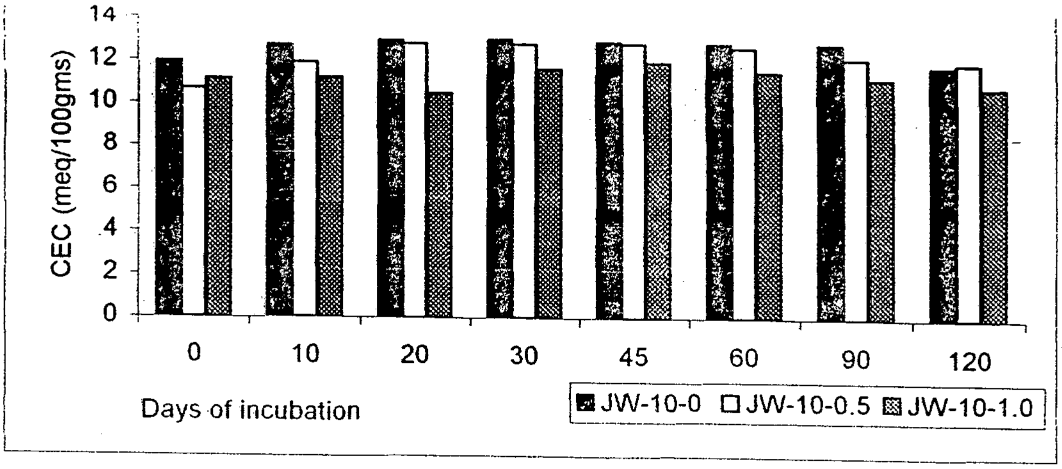


Graph 4.14

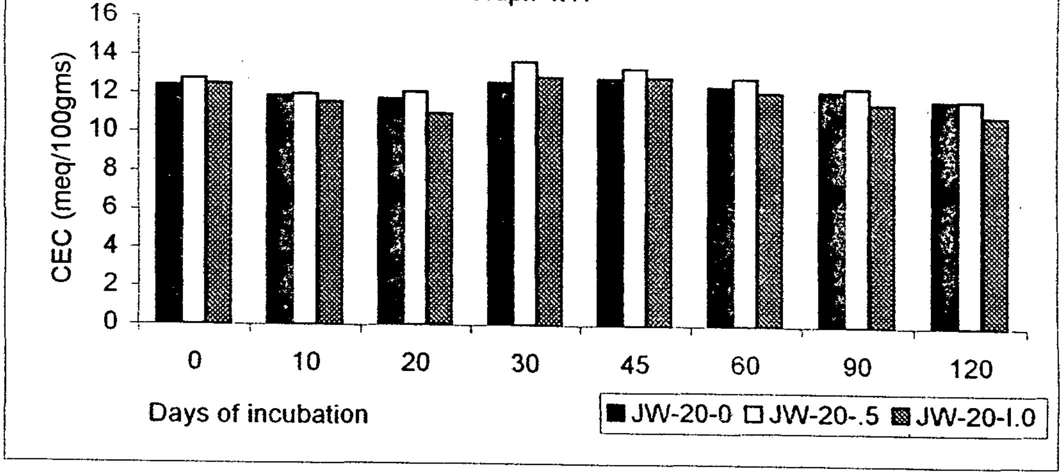


Graph 4.15

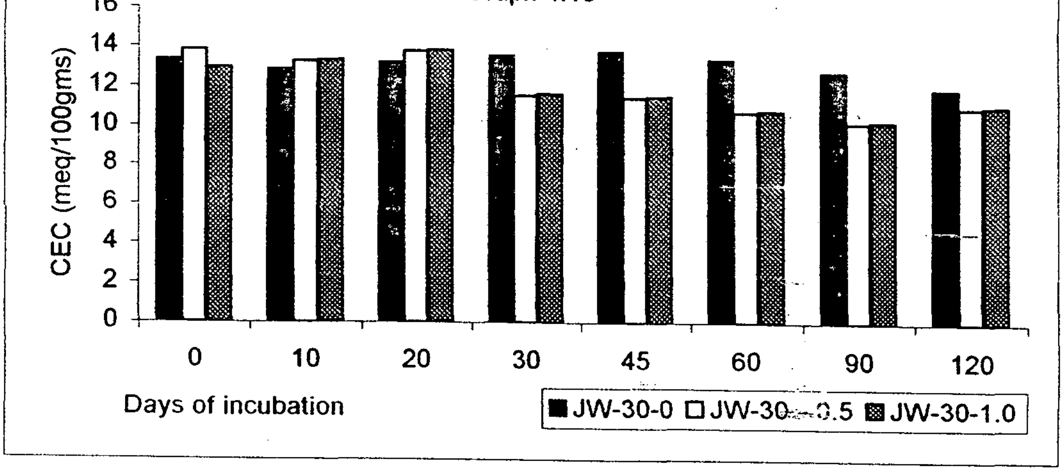
Graph 4.16



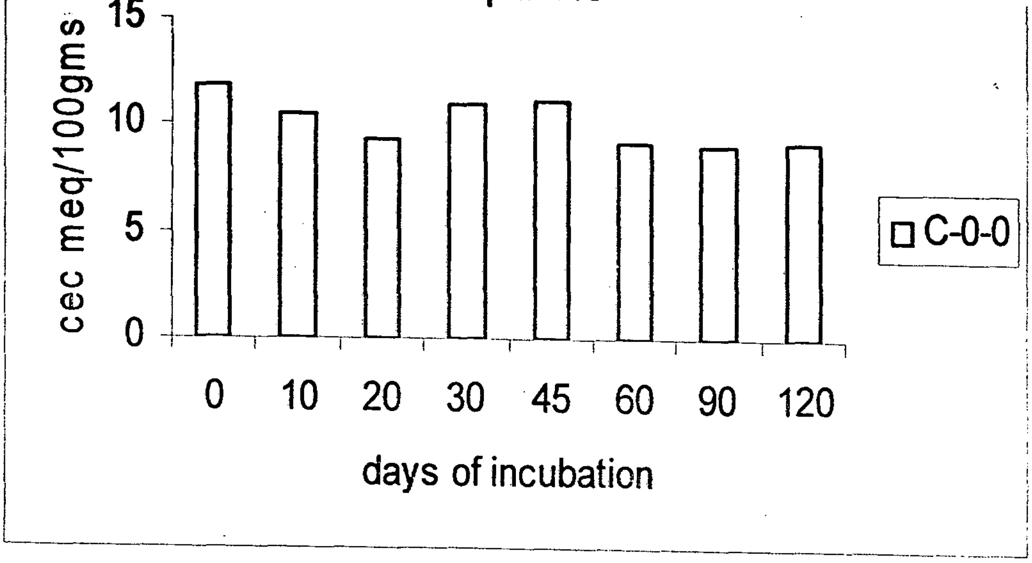
Graph 4.17



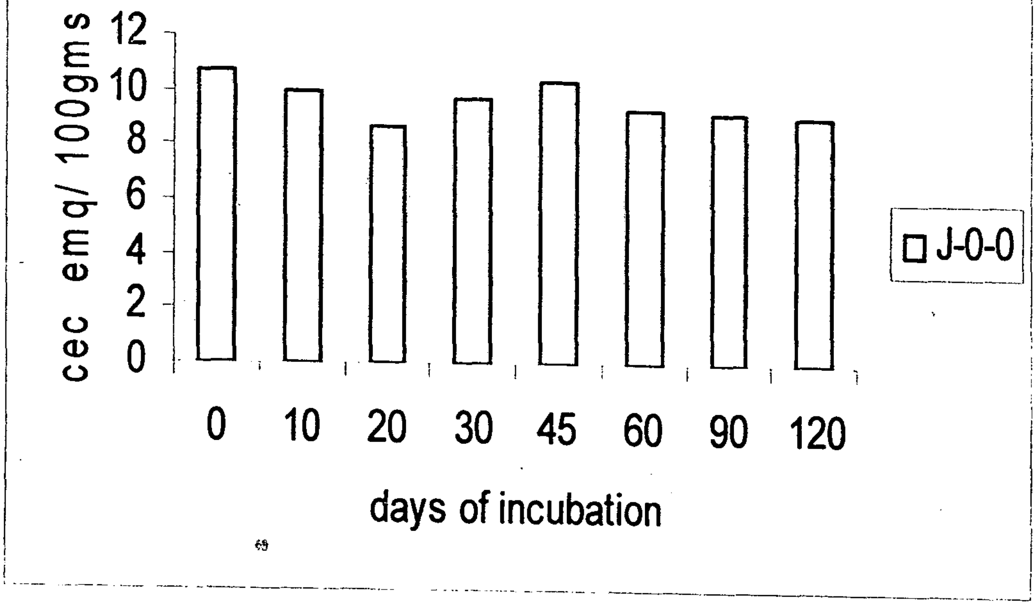
Graph 4.18



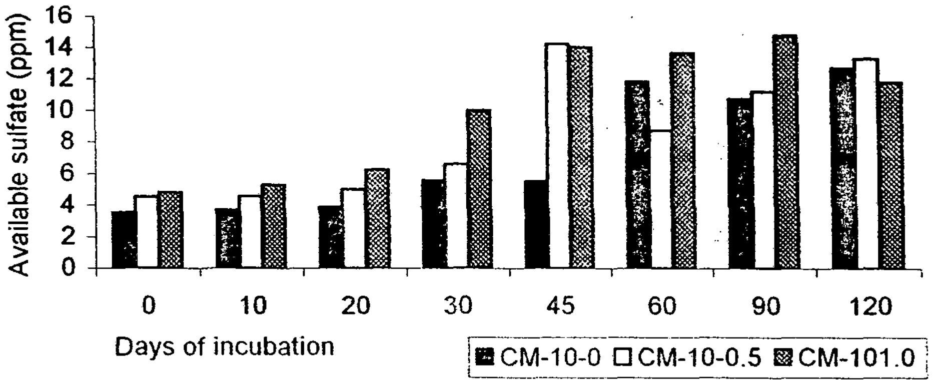
Graph.4.19



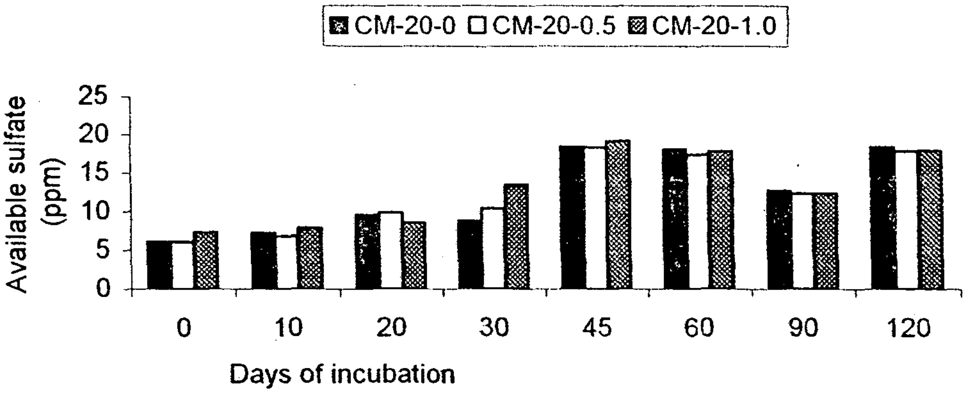
graph 4.20



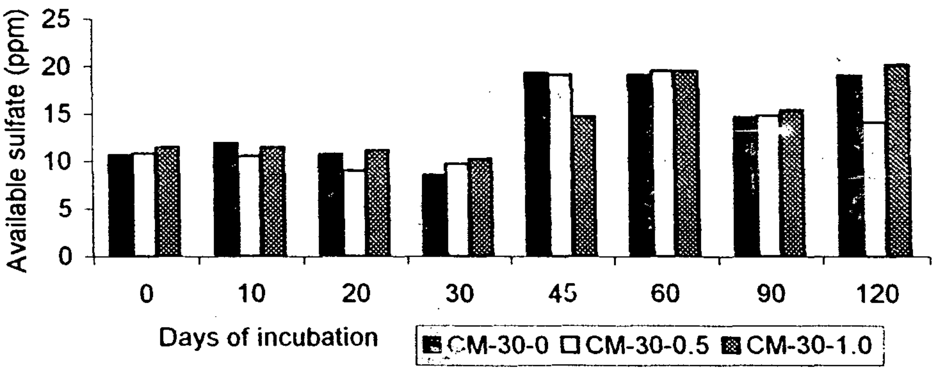
Graph 5.1

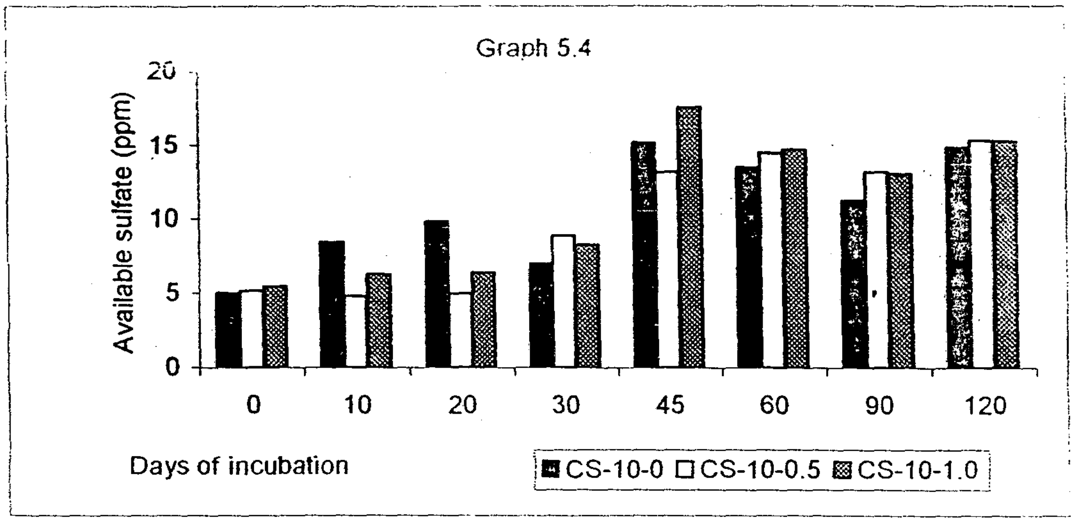


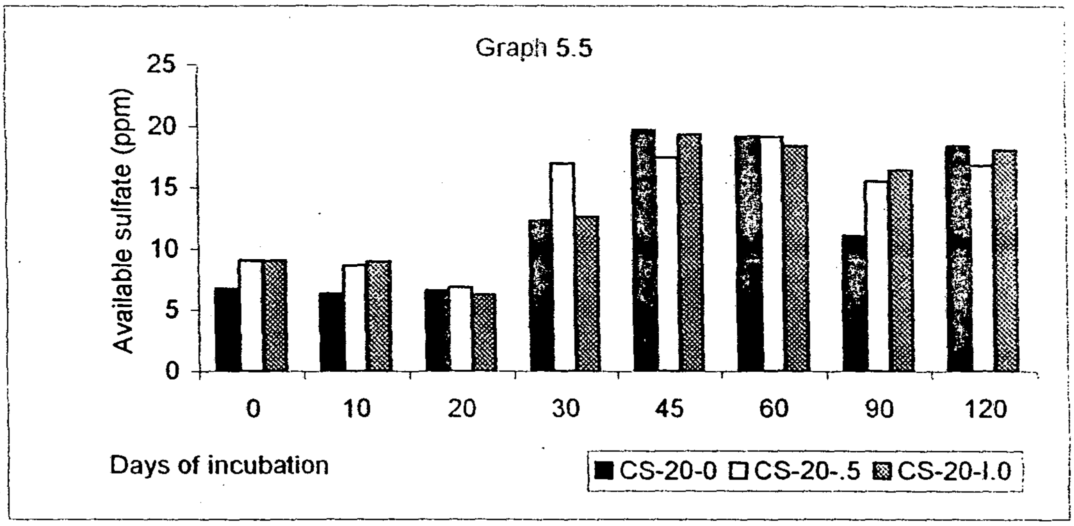
Graph 5.2

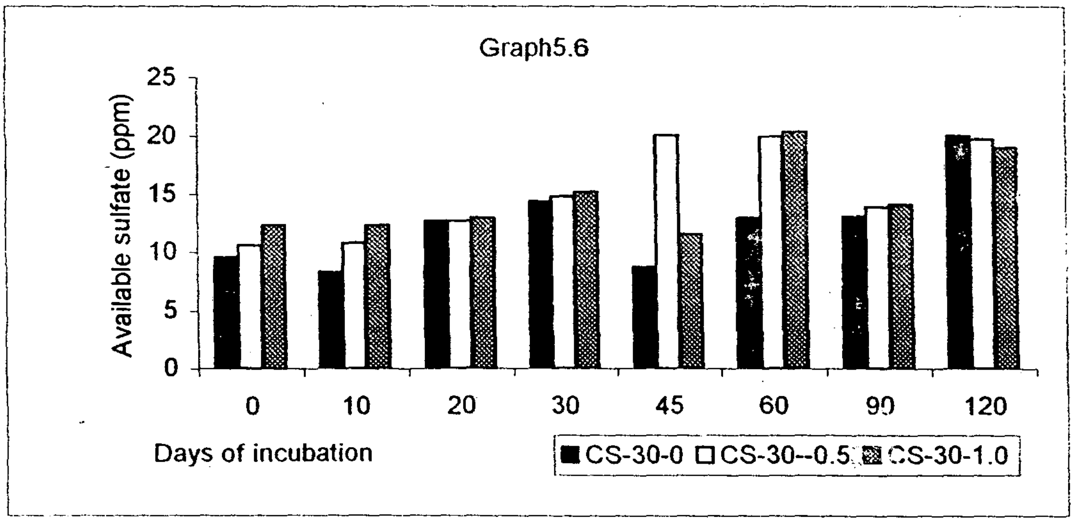


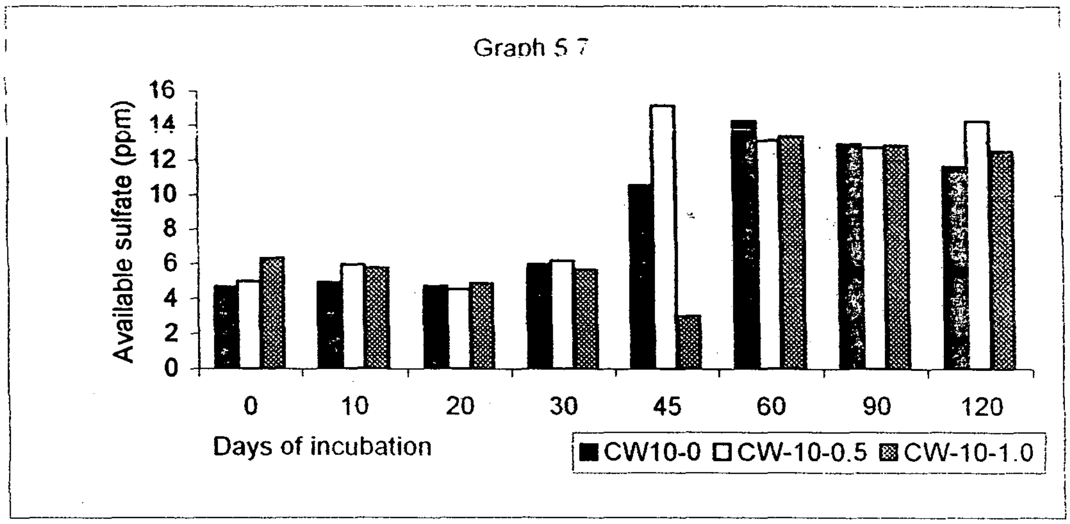
Graph 5.3

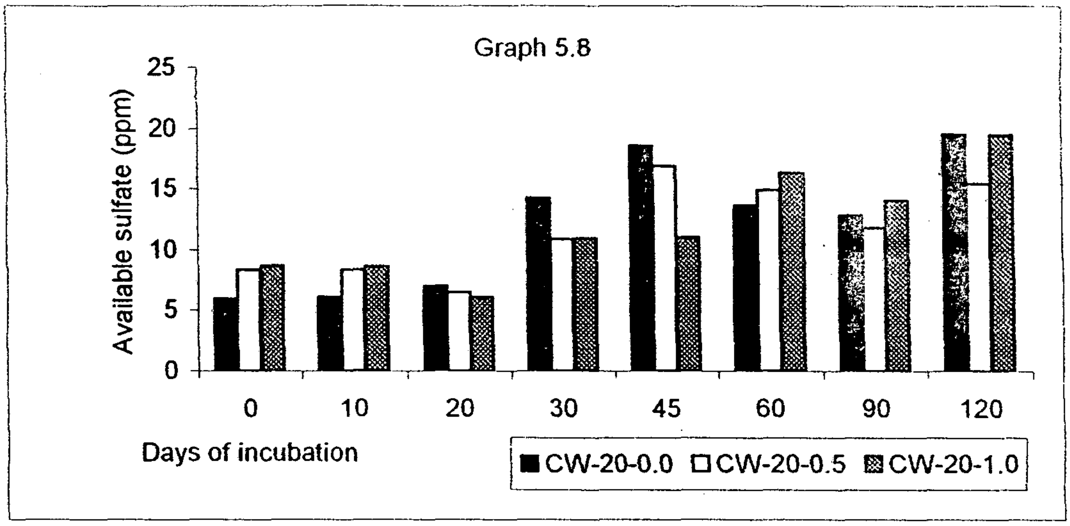


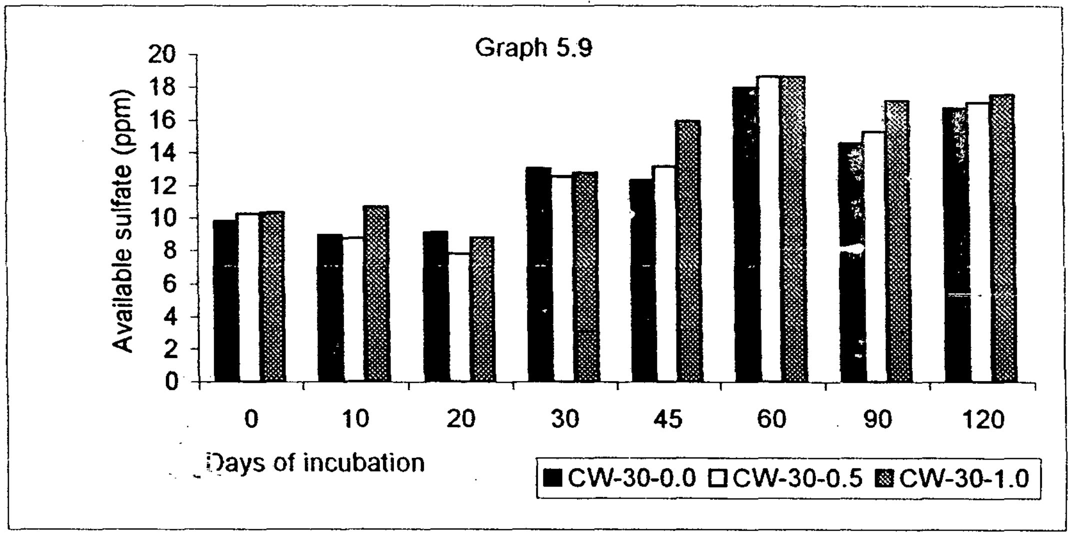

Graph 5.4
Available sulfate (ppm)
0
5
10
15
20
0
10
20
30
45
60
90
120
Days of incubation
■ CS-10-0 ☐ CS-10-0.5 ▨ CS-10-1.0

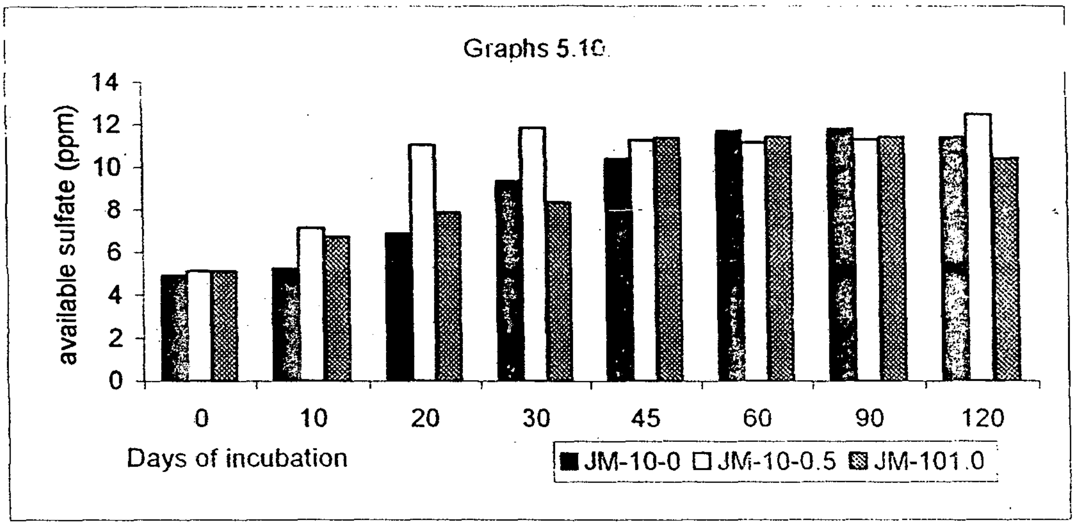

Graph 5.5
Available sulfate (ppm)
0
5
10
15
20
25
0
10
20
30
45
60
90
120
Days of incubation
■ CS-20-0 ☐ CS-20-.5 ▨ CS-20-I.0

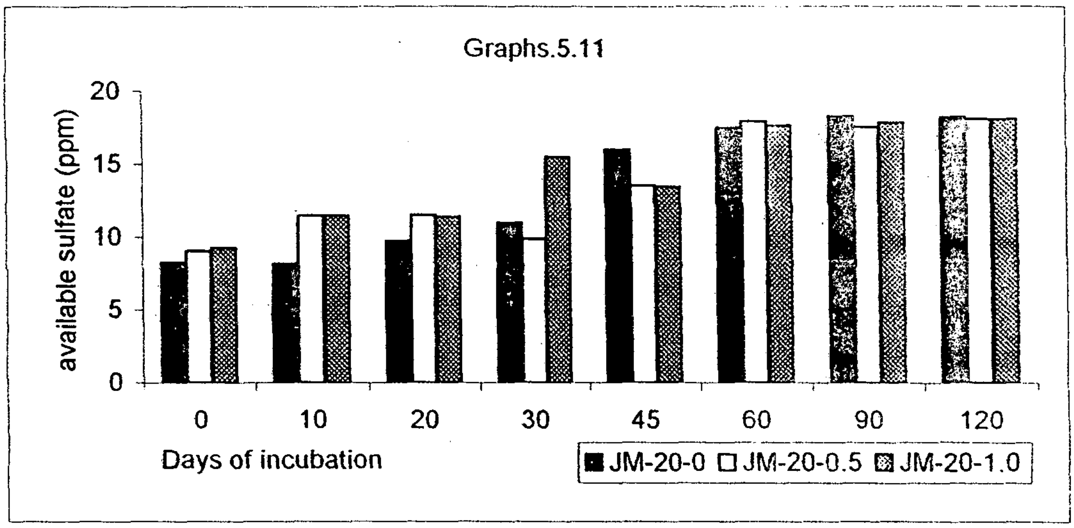

Graph5.6
Available sulfate (ppm)
0
5
10
15
20
25
0
10
20
30
45
60
90
120
Days of incubation
■ CS-30-0 ☐ CS-30--0.5 ▨ CS-30-1.0

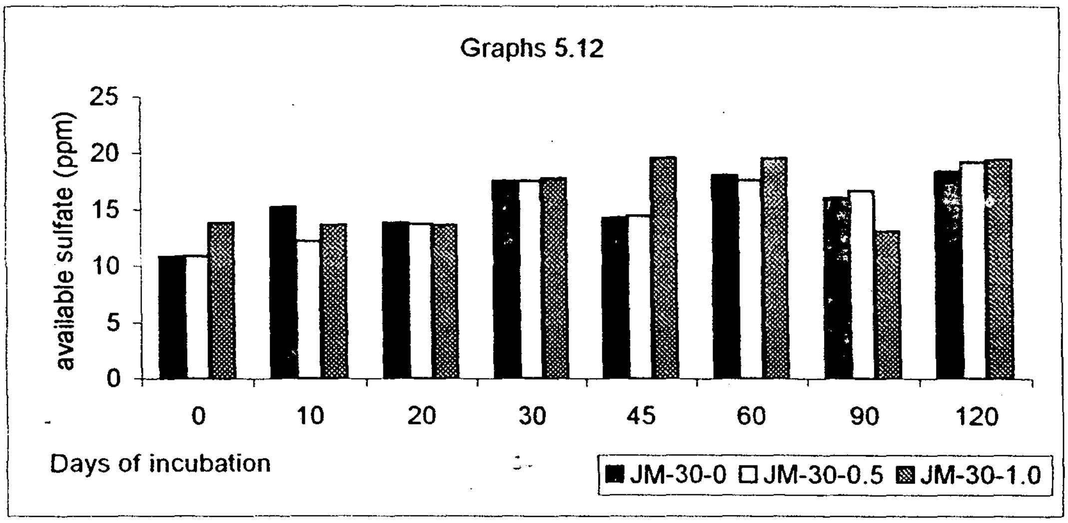

Graph 5.7
Available sulfate (ppm)
0
2
4
6
8
10
12
14
16
0
10
20
30
45
60
90
120
Days of incubation
■CW10-0
□CW-10-0.5
▨CW-10-1.0

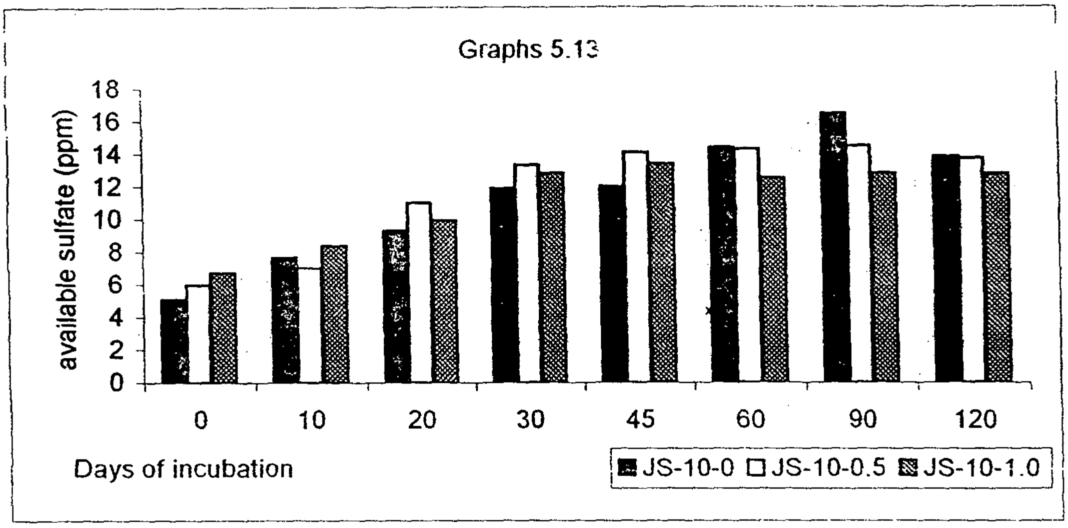

Graph 5.8
Available sulfate (ppm)
0
5
10
15
20
25
0
10
20
30
45
60
90
120
Days of incubation
■CW-20-0.0
□CW-20-0.5
▨CW-20-1.0

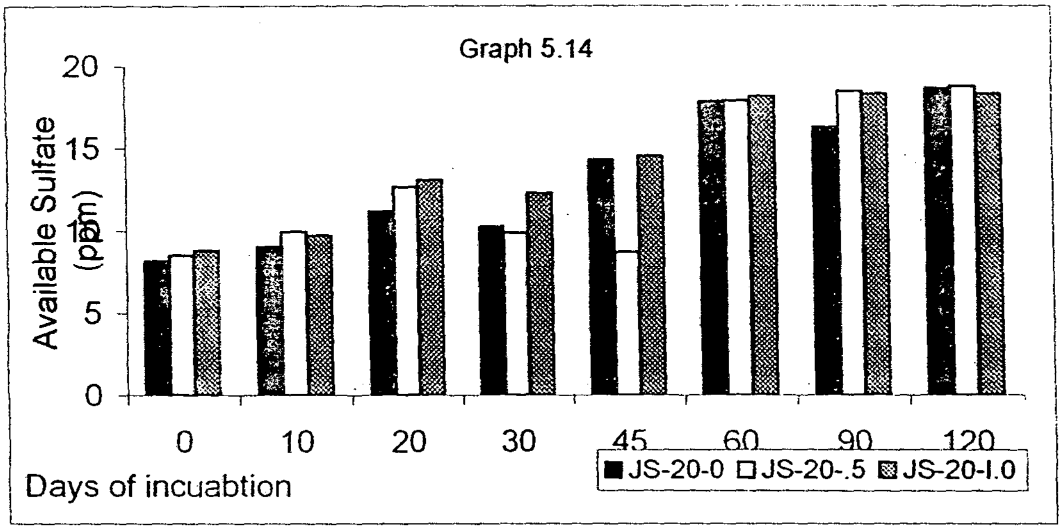

Graph 5.9
Available sulfate (ppm)
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
45
60
90
120
Days of incubation
■CW-30-0.0
□CW-30-0.5
▨CW-30-1.0

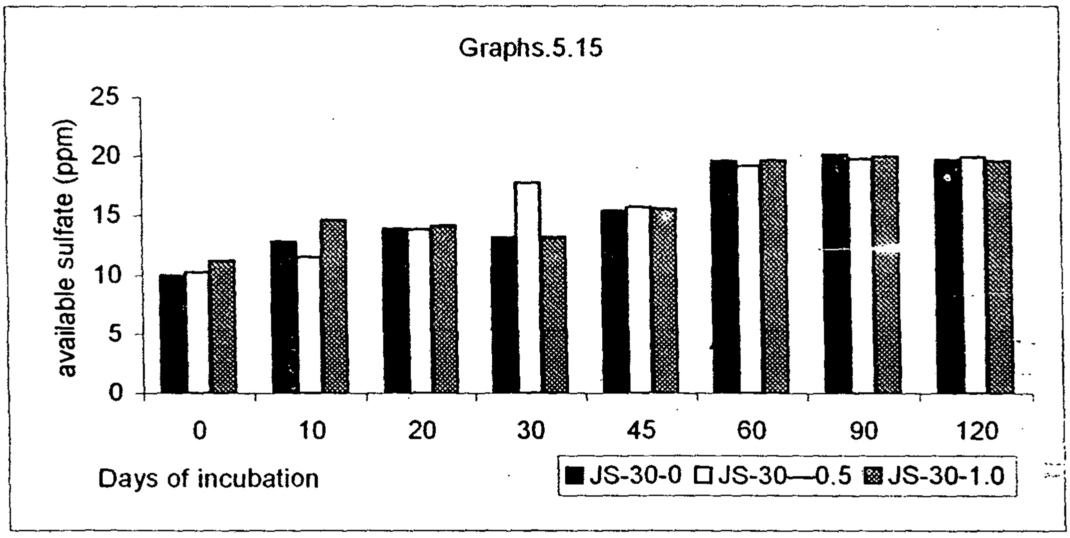

Graphs 5.10
available sulfate (ppm)
0
2
4
6
8
10
12
14
0
10
20
30
45
60
90
120
Days of incubation
■ JM-10-0 □ JM-10-0.5 ▨ JM-101.0


Graphs.5.11
available sulfate (ppm)
0
5
10
15
20
0
10
20
30
45
60
90
120
Days of incubation
■ JM-20-0 □ JM-20-0.5 ▨ JM-20-1.0

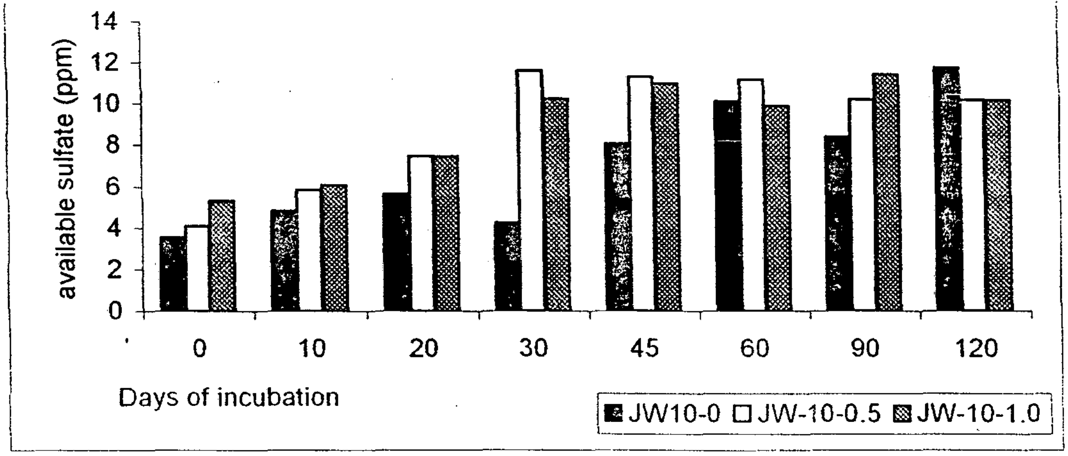

Graphs 5.12
available sulfate (ppm)
0
5
10
15
20
25
0
10
20
30
45
60
90
120
Days of incubation
■ JM-30-0 □ JM-30-0.5 ▨ JM-30-1.0


Graphs 5.13

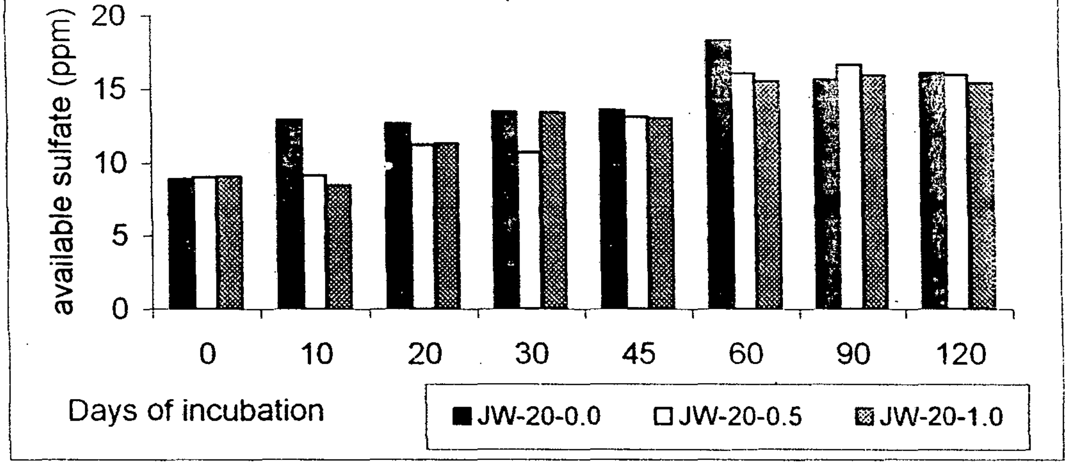

Graph 5.14


Graphs.5.15

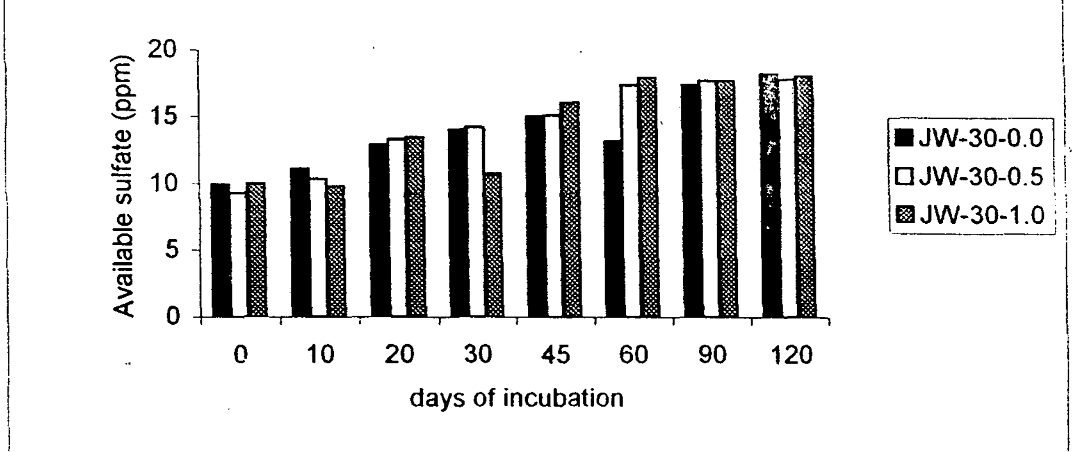
Graphs 5.16

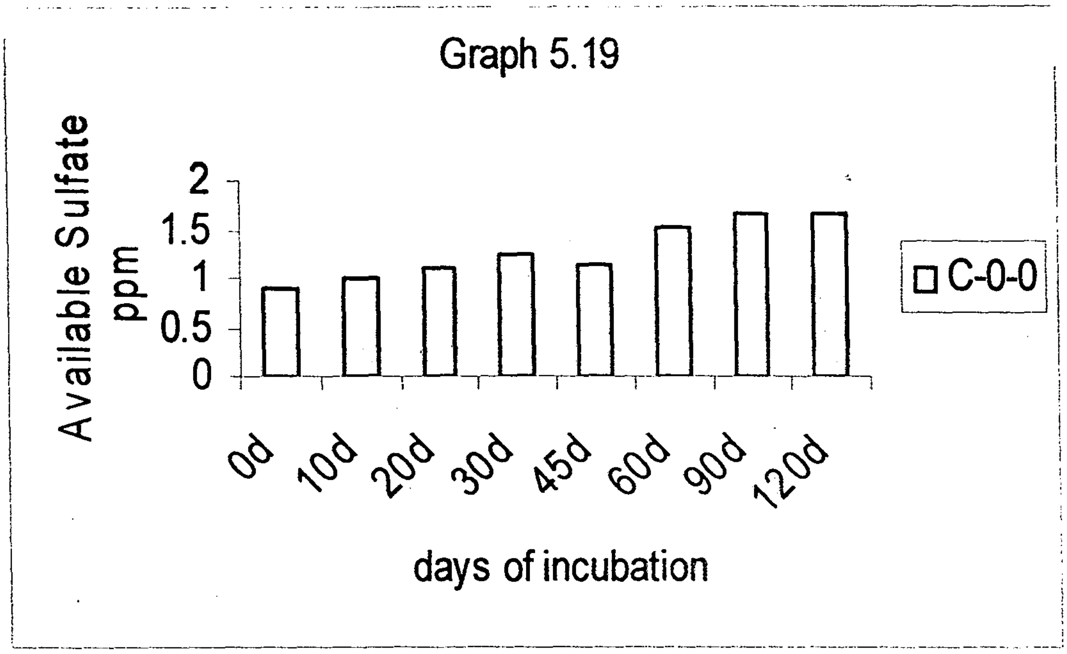


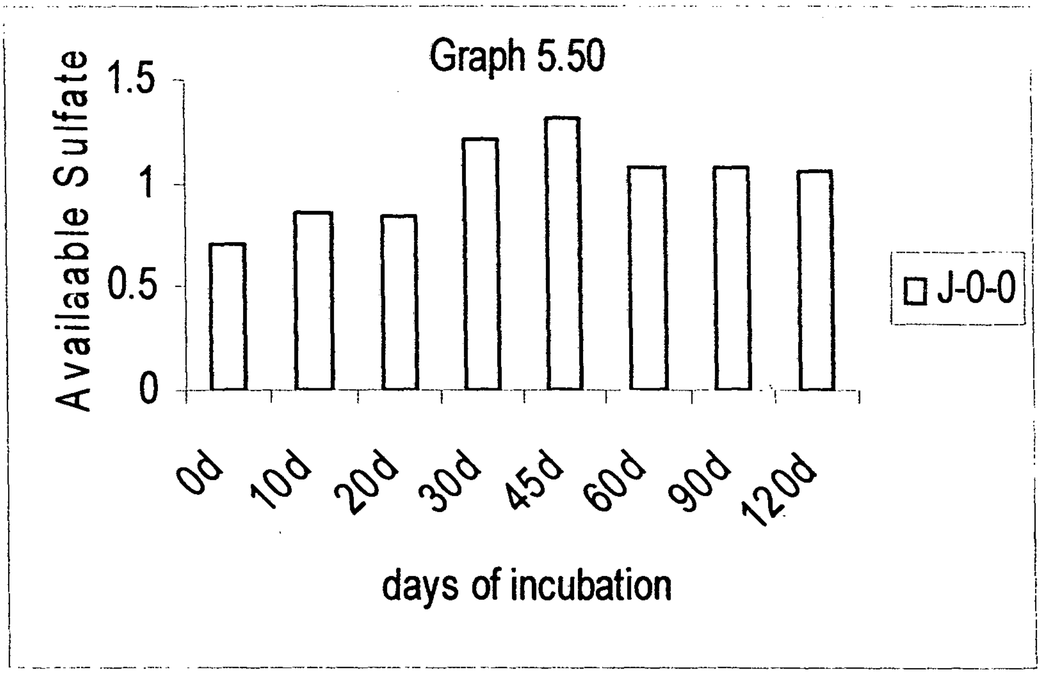
Graphs 5.17

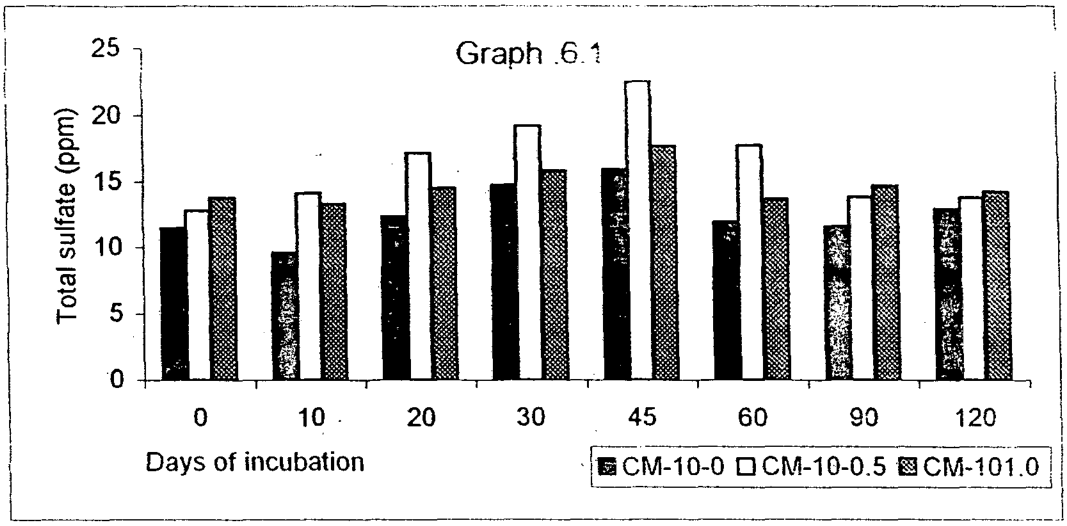


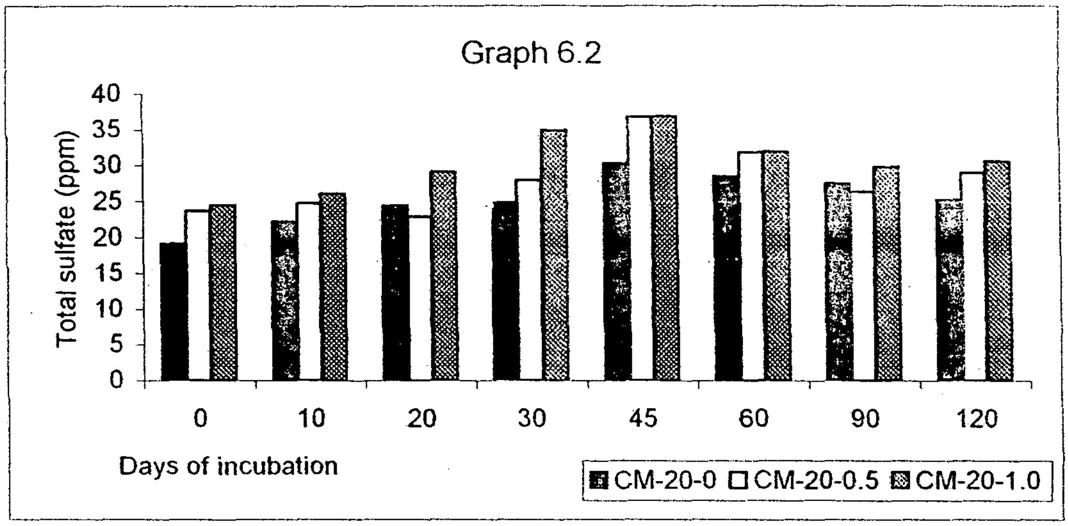
Graphs 5.18

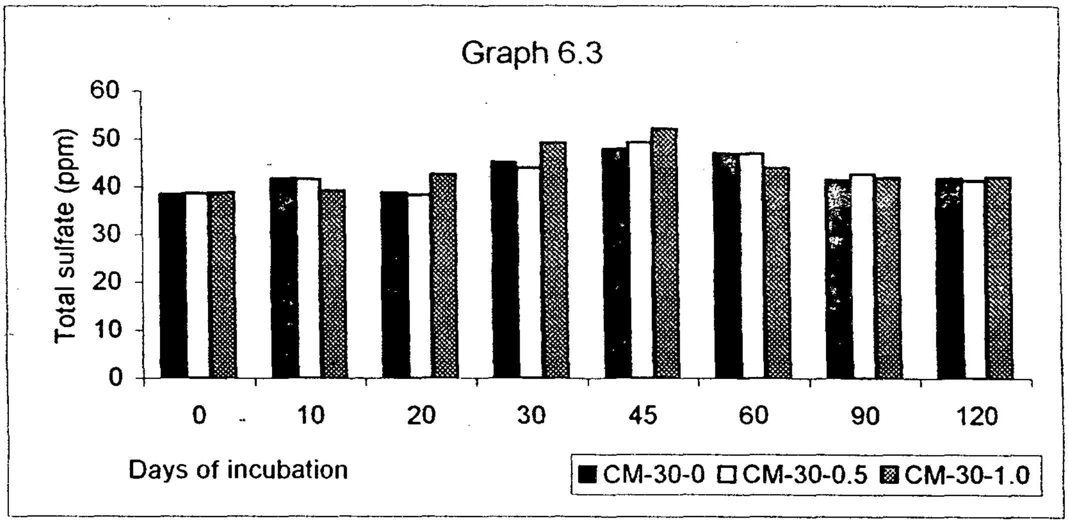


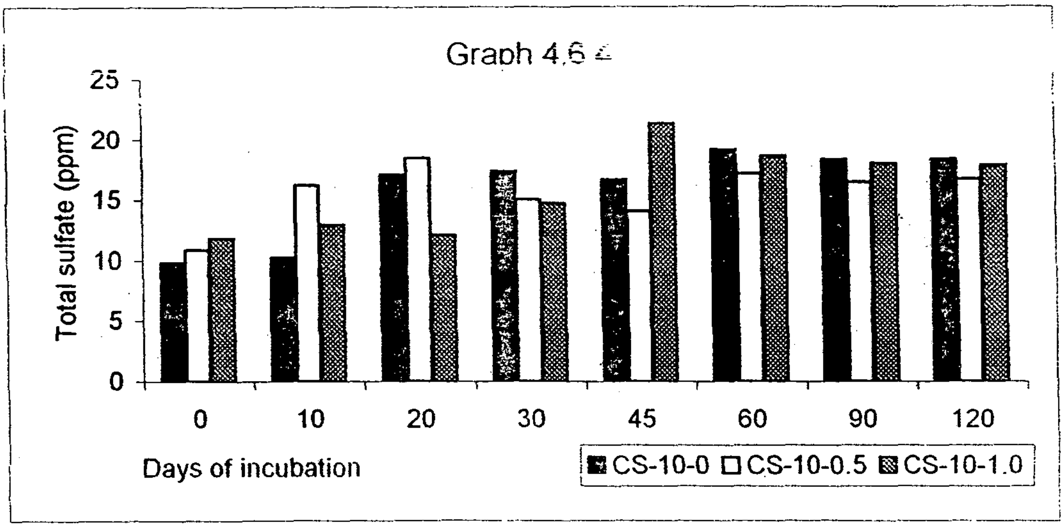

Graph 5.19
Available Sulfate ppm
2
1.5
1
0.5
0
0d
10d
20d
30d
45d
60d
90d
120d
days of incubation
□ C-0-0

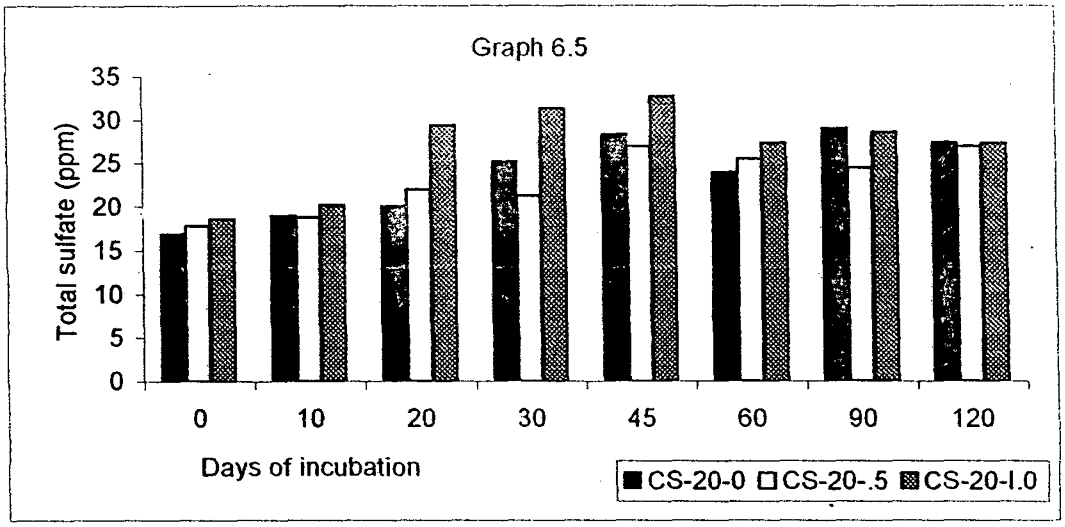

Graph 5.50
Availaable Sulfate
1.5
1
0.5
0
0d
10d
20d
30d
45d
60d
90d
120d
days of incubation
□ J-0-0

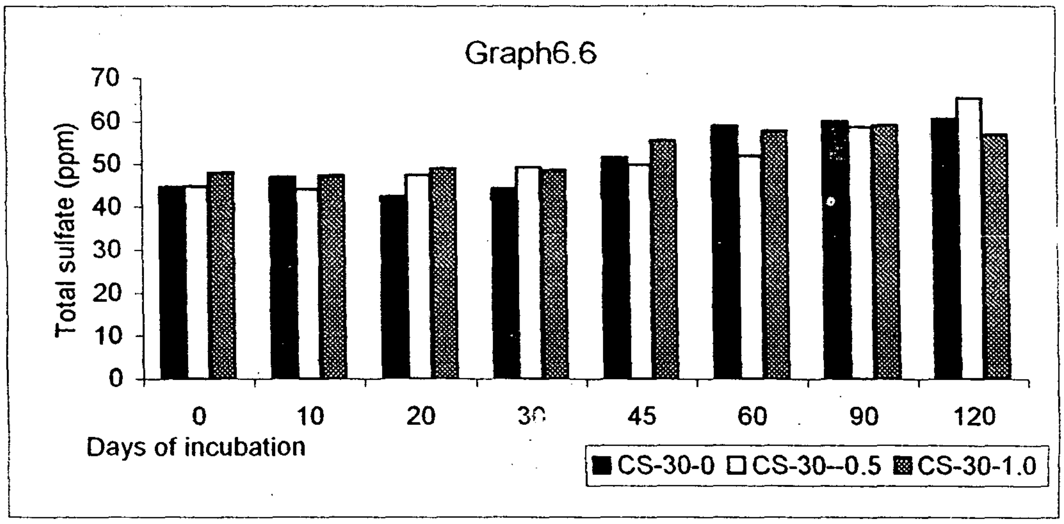

Graph .6.1
Total sulfate (ppm)
25
20
15
10
5
0
0
10
20
30
45
60
90
120
Days of incubation
■ CM-10-0 ☐ CM-10-0.5 ▨ CM-101.0

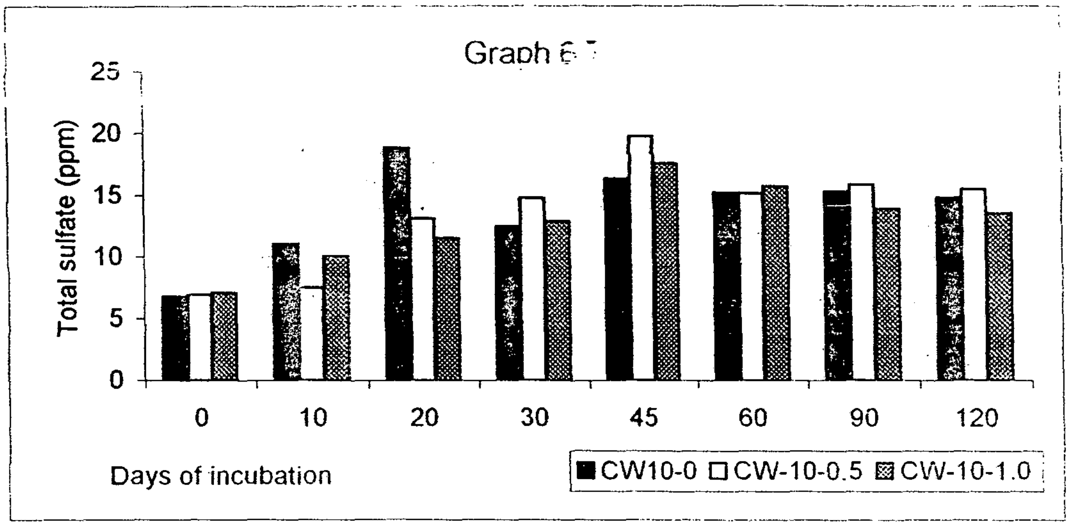

Graph 6.2
Total sulfate (ppm)
40
35
30
25
20
15
10
5
0
0
10
20
30
45
60
90
120
Days of incubation
■ CM-20-0 ☐ CM-20-0.5 ▨ CM-20-1.0

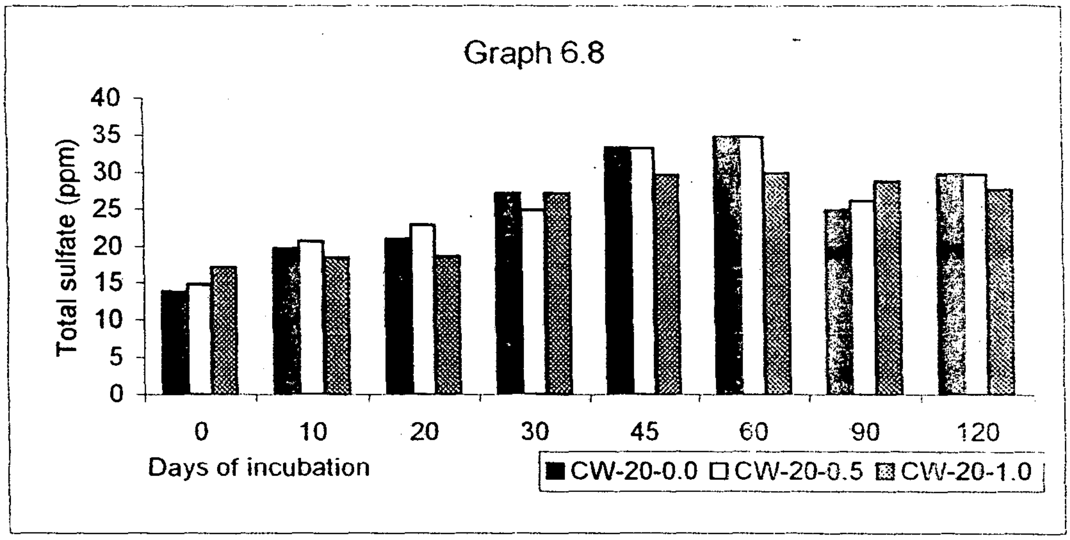

Graph 6.3
Total sulfate (ppm)
60
50
40
30
20
10
0
0
10
20
30
45
60
90
120
Days of incubation
■ CM-30-0 ☐ CM-30-0.5 ▨ CM-30-1.0

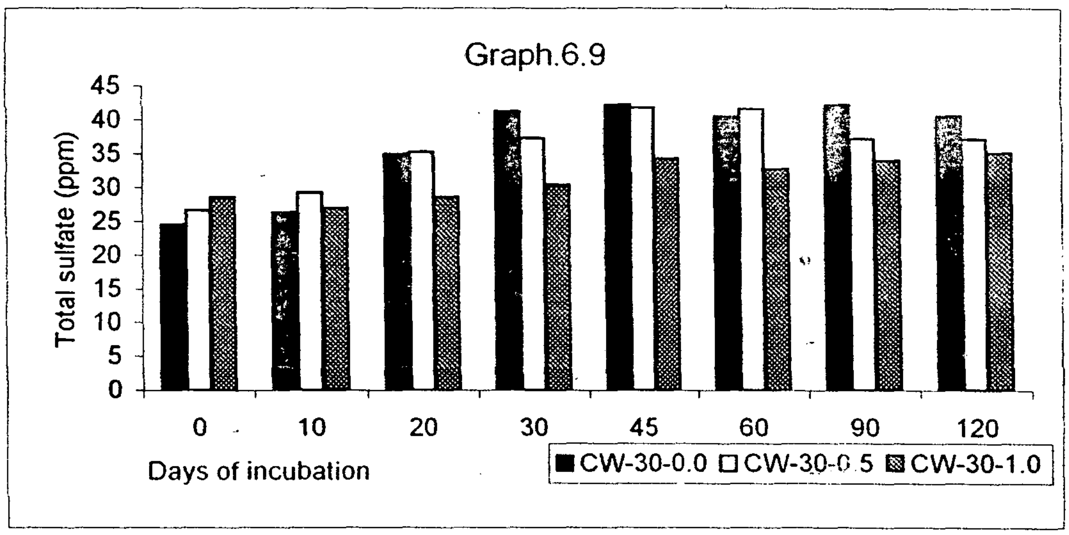

Graph 4.6 4
Total sulfate (ppm)
25
20
15
10
5
0
0
10
20
30
45
60
90
120
Days of incubation
CS-10-0
CS-10-0.5
CS-10-1.0

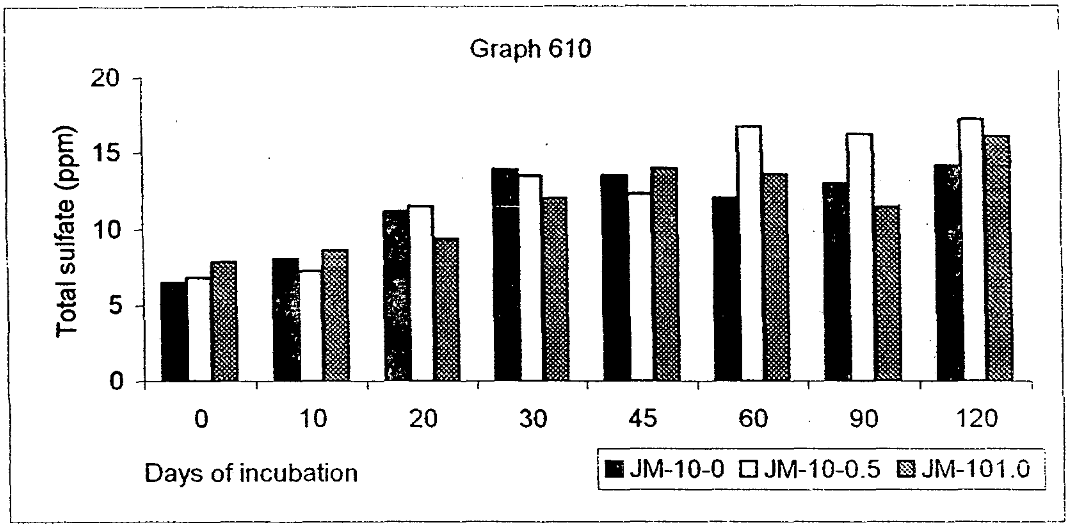

Graph 6.5
Total sulfate (ppm)
35
30
25
20
15
10
5
0
0
10
20
30
45
60
90
120
Days of incubation
CS-20-0
CS-20-.5
CS-20-I.0


Graph6.6
Total sulfate (ppm)
70
60
50
40
30
20
10
0
0
10
20
30
45
60
90
120
Days of incubation
CS-30-0
CS-30--0.5
CS-30-1.0

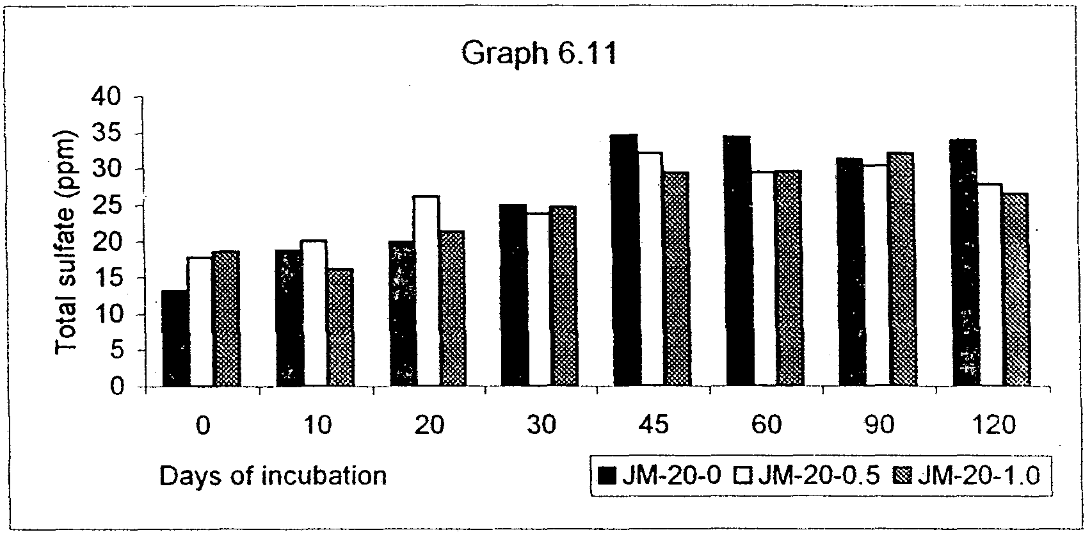

Graph 6.7
Total sulfate (ppm)
25
20
15
10
5
0
0
10
20
30
45
60
90
120
Days of incubation
■ CW10-0
□ CW-10-0.5
▨ CW-10-1.0


Graph 6.8
Total sulfate (ppm)
40
35
30
25
20
15
10
5
0
0
10
20
30
45
60
90
120
Days of incubation
■ CW-20-0.0
□ CW-20-0.5
▨ CW-20-1.0

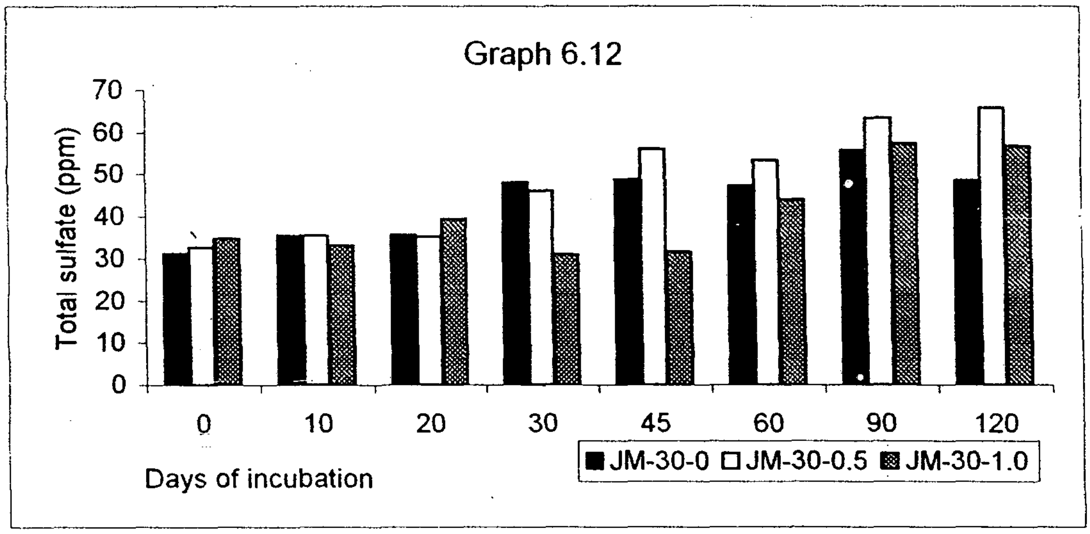

Graph.6.9
Total sulfate (ppm)
45
40
35
30
25
20
15
10
5
0
0
10
20
30
45
60
90
120
Days of incubation
■ CW-30-0.0
□ CW-30-0.5
▨ CW-30-1.0



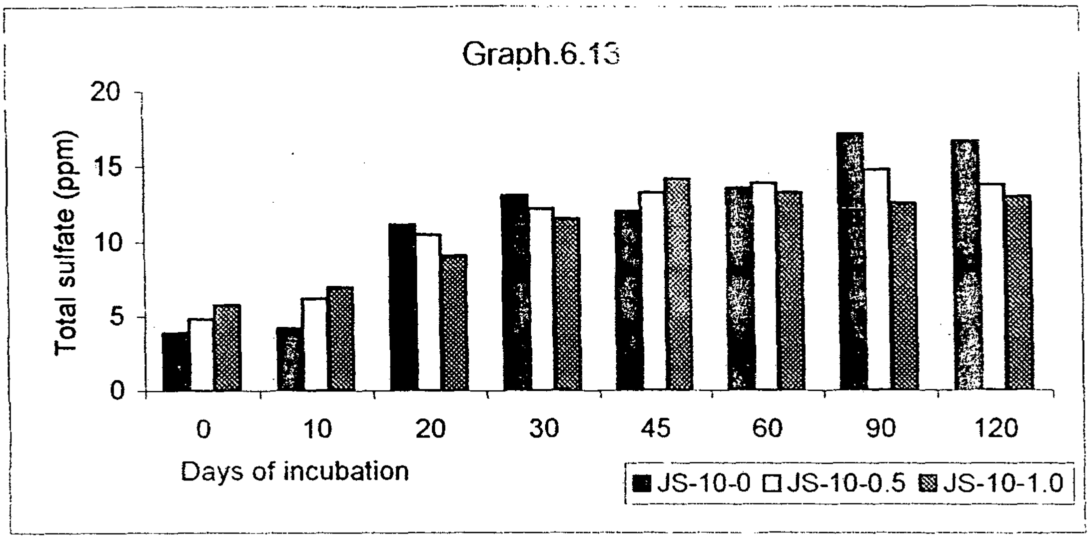
Graph 610

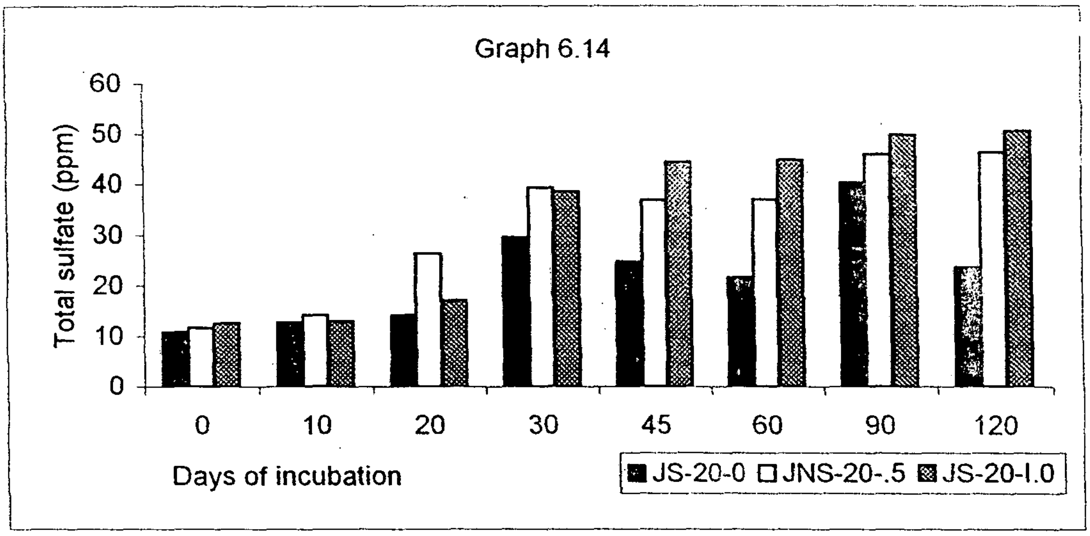


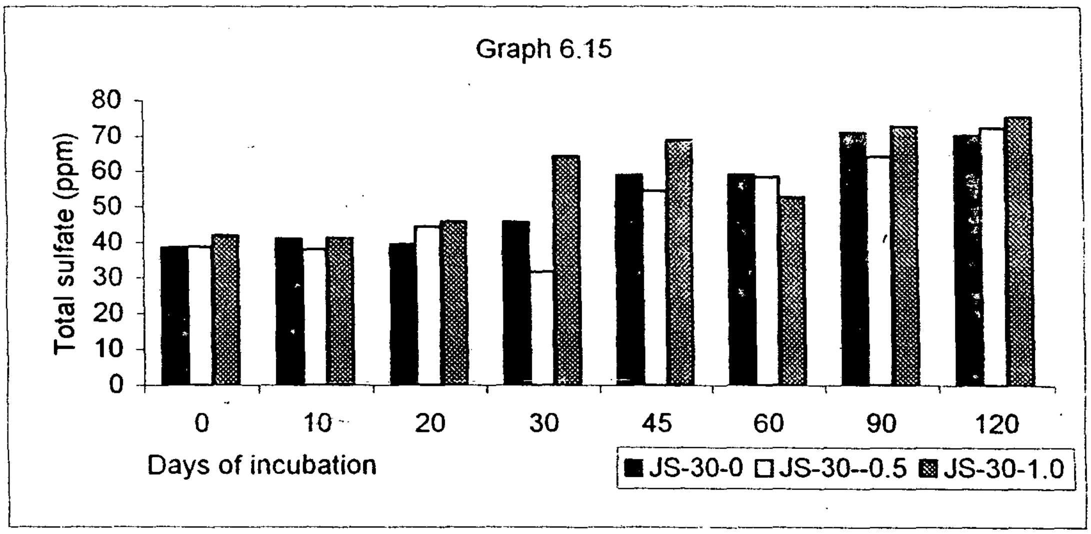
Graph 6.11

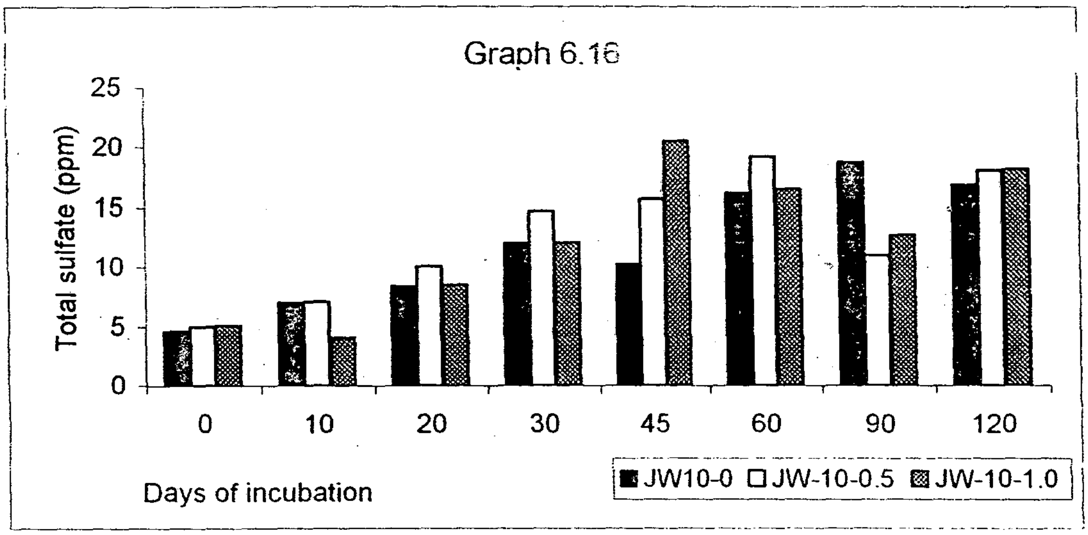


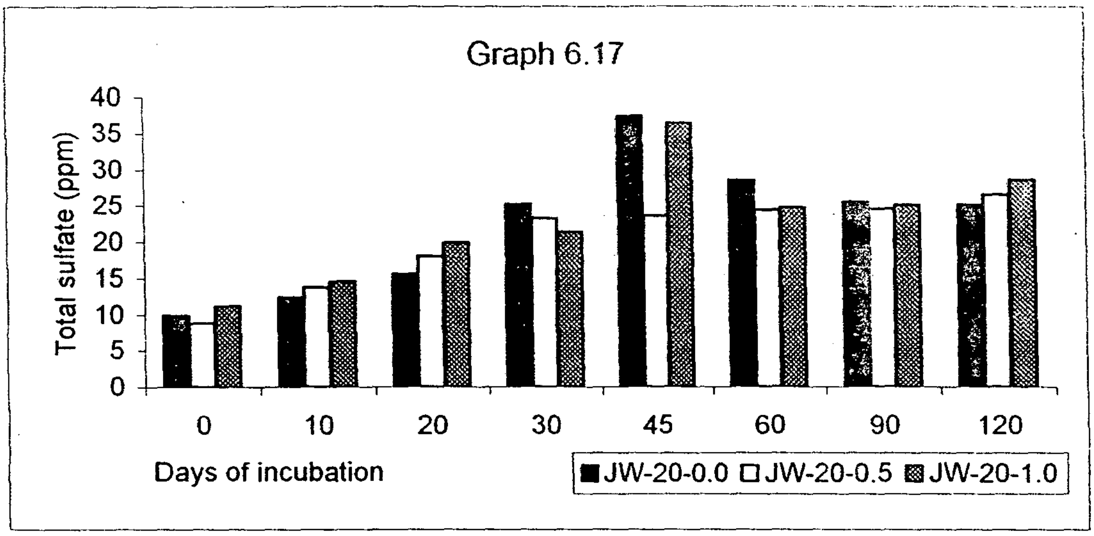
Graph 6.12

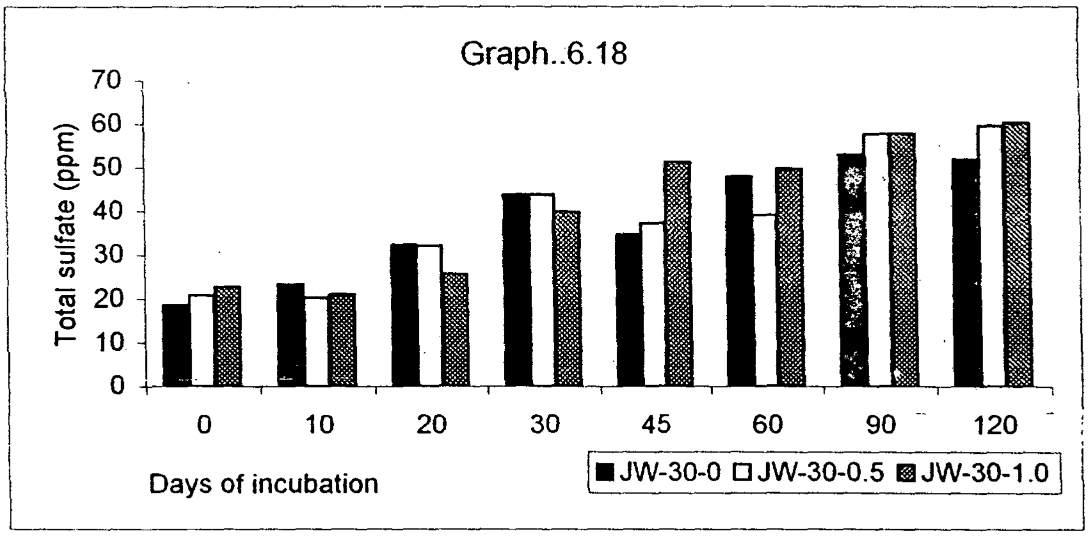

Graph.6.13
Total sulfate (ppm)
0
5
10
15
20
0
10
20
30
45
60
90
120
Days of incubation
■ JS-10-0 ☐ JS-10-0.5 ▨ JS-10-1.0

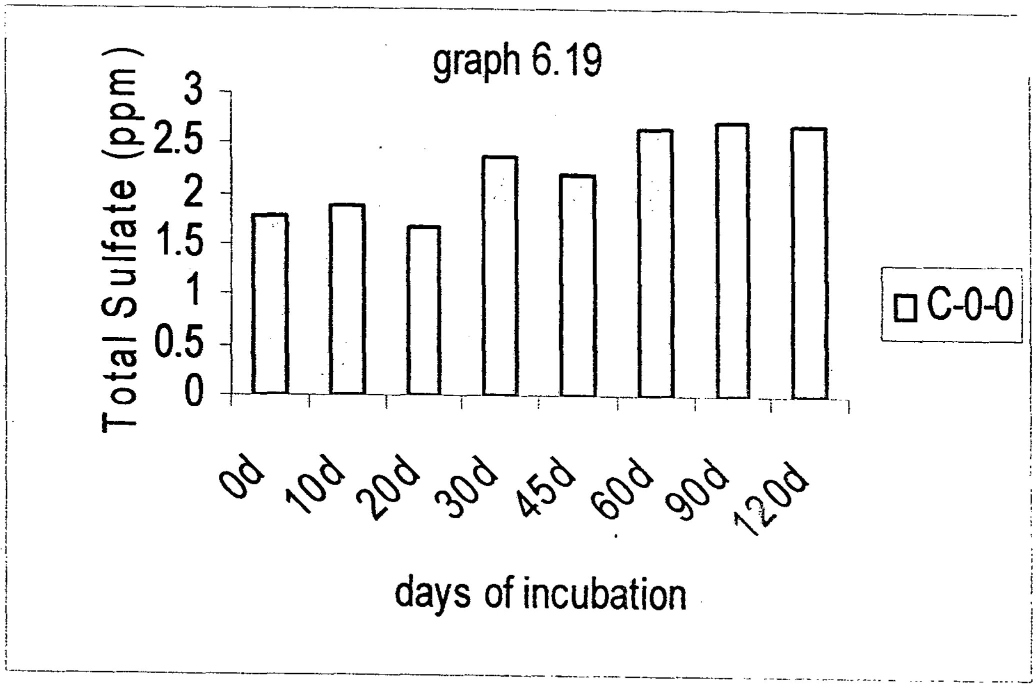

Graph 6.14
Total sulfate (ppm)
0
10
20
30
40
50
60
0
10
20
30
45
60
90
120
Days of incubation
■ JS-20-0 ☐ JNS-20-.5 ▨ JS-20-I.0

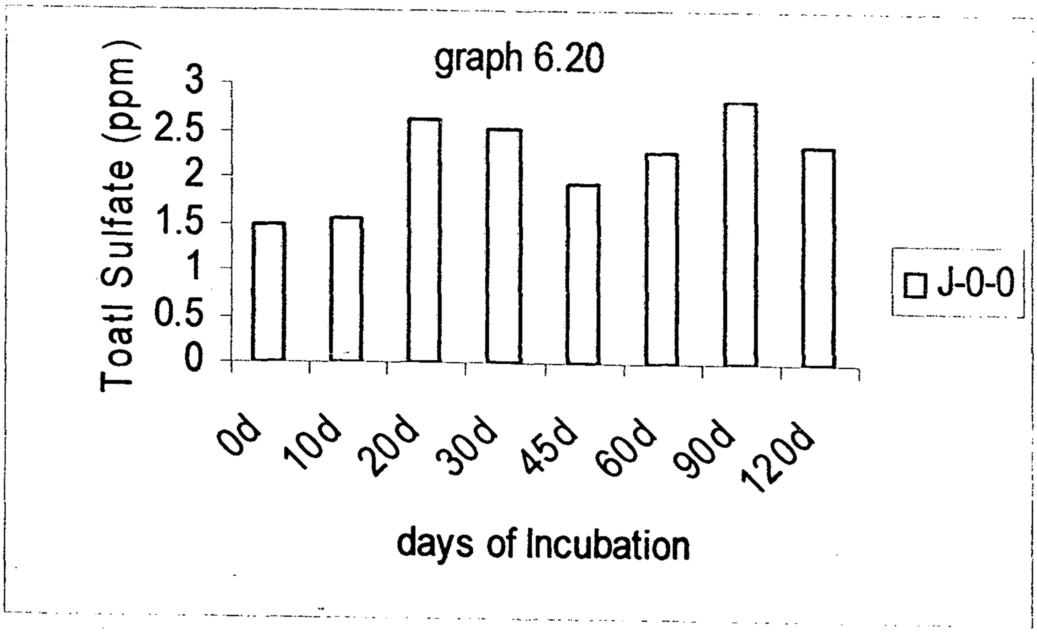

Graph 6.15
Total sulfate (ppm)
0
10
20
30
40
50
60
70
80
0
10
20
30
45
60
90
120
Days of incubation
■ JS-30-0 ☐ JS-30--0.5 ▨ JS-30-1.0

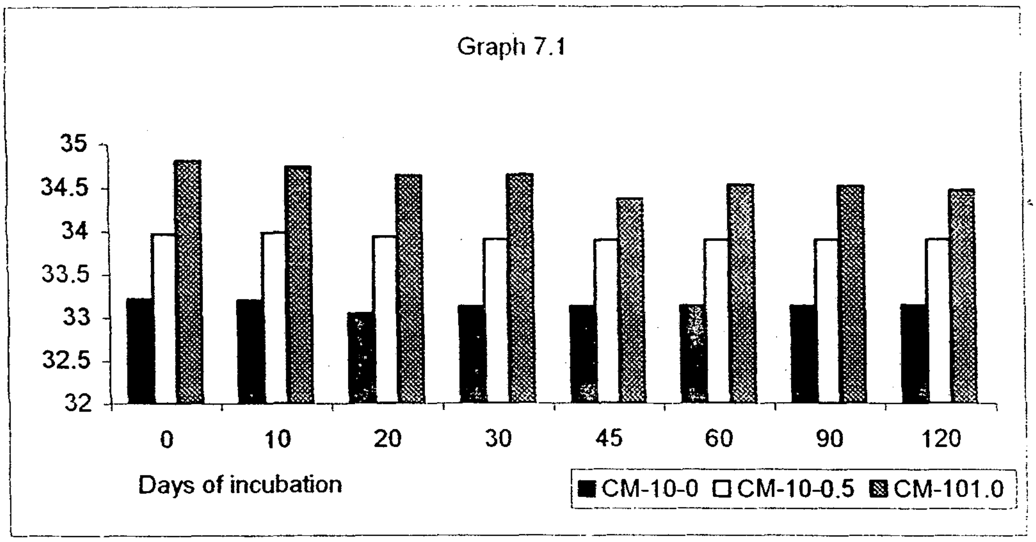

Graph 6.16

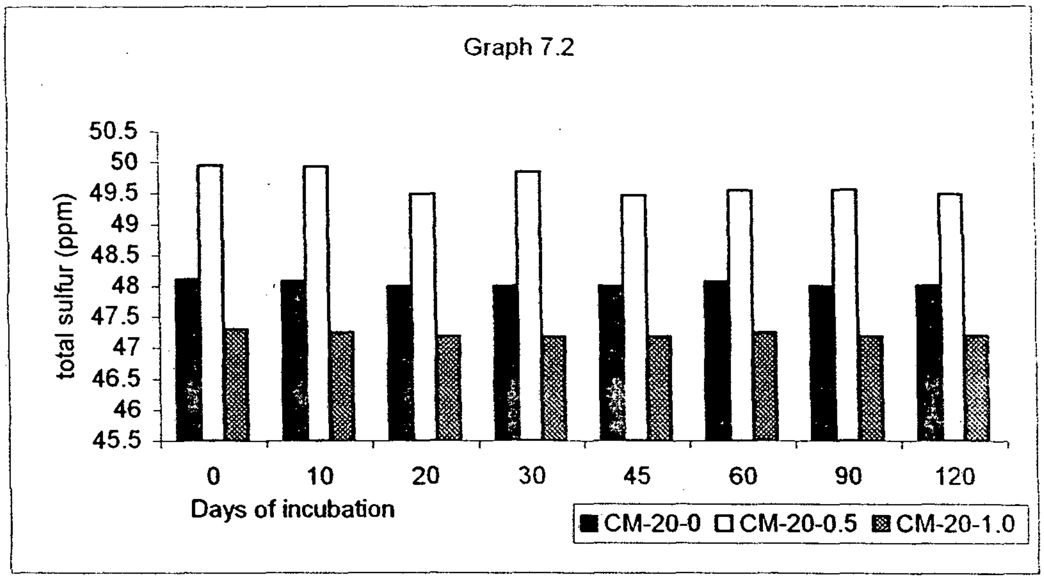

Graph 6.17

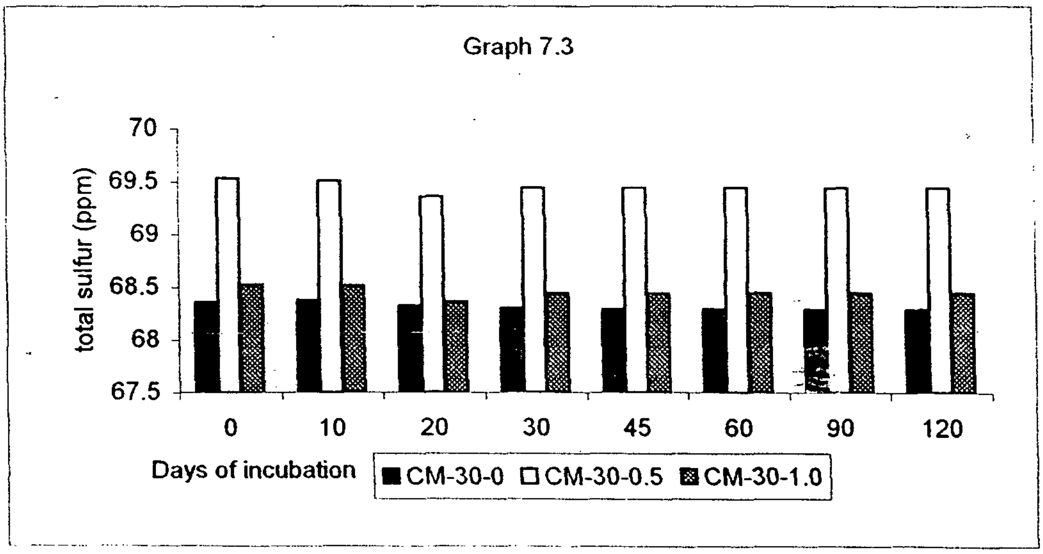

Graph..6.18

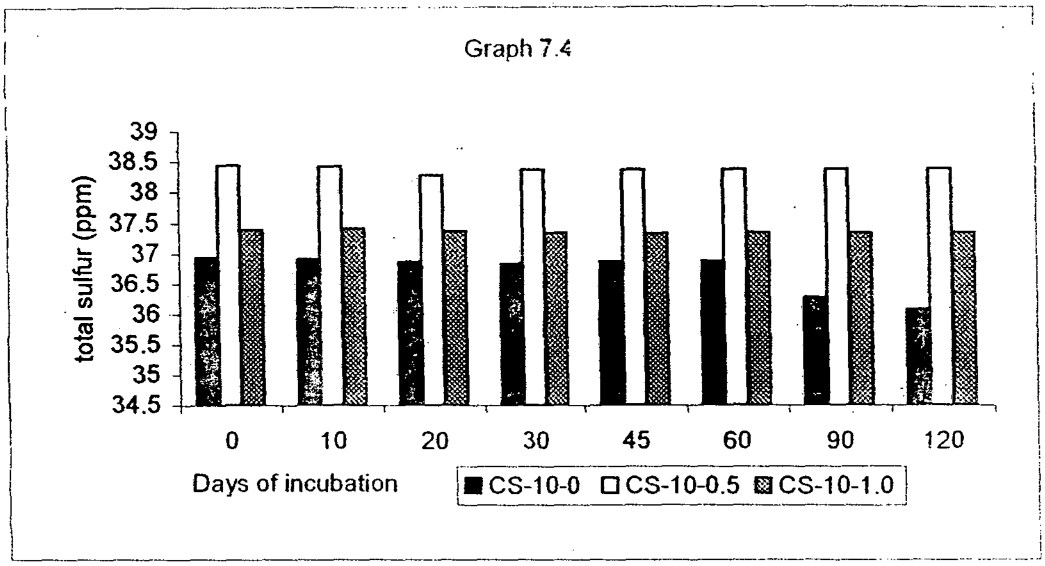

graph 6.19
Total Sulfate (ppm)
3
2.5
2
1.5
1
0.5
0
0d
10d
20d
30d
45d
60d
90d
120d
days of incubation
□ C-0-0

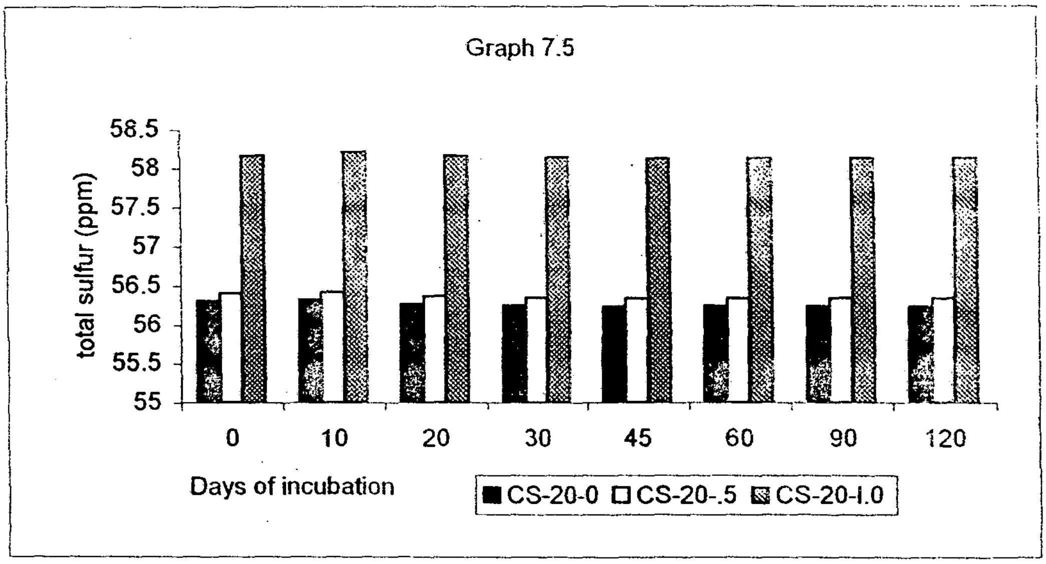

graph 6.20
Toatl Sulfate (ppm)
3
2.5
2
1.5
1
0.5
0
0d
10d
20d
30d
45d
60d
90d
120d
days of Incubation
□ J-0-0

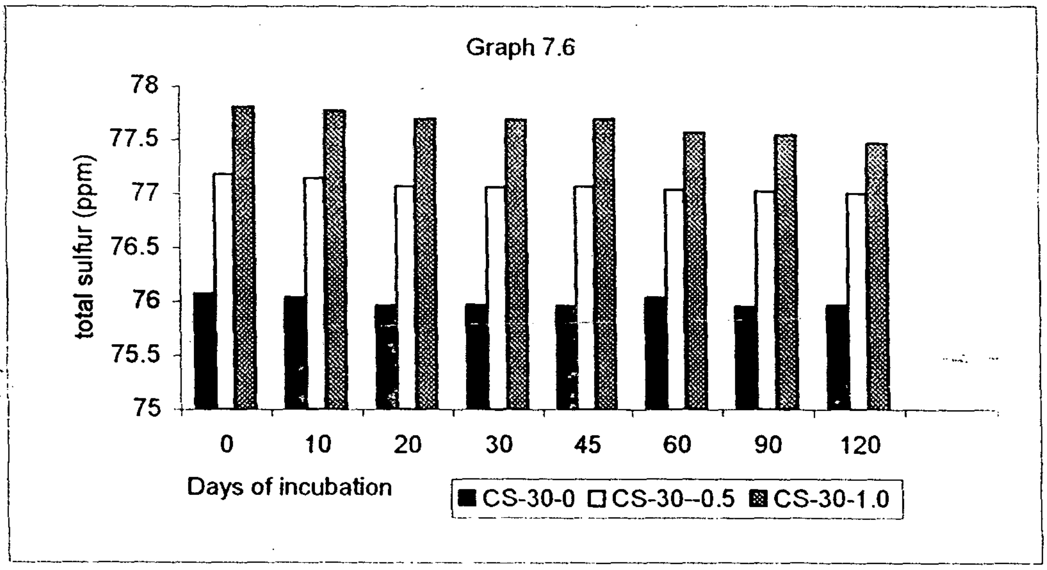

Graph 7.1
35
34.5
34
33.5
33
32.5
32
0
10
20
30
45
60
90
120
Days of incubation
■CM-10-0 □CM-10-0.5 ▨CM-101.0


Graph 7.2
total sulfur (ppm)
50.5
50
49.5
49
48.5
48
47.5
47
46.5
46
45.5
0
10
20
30
45
60
90
120
Days of incubation
■CM-20-0 □CM-20-0.5 ▨CM-20-1.0

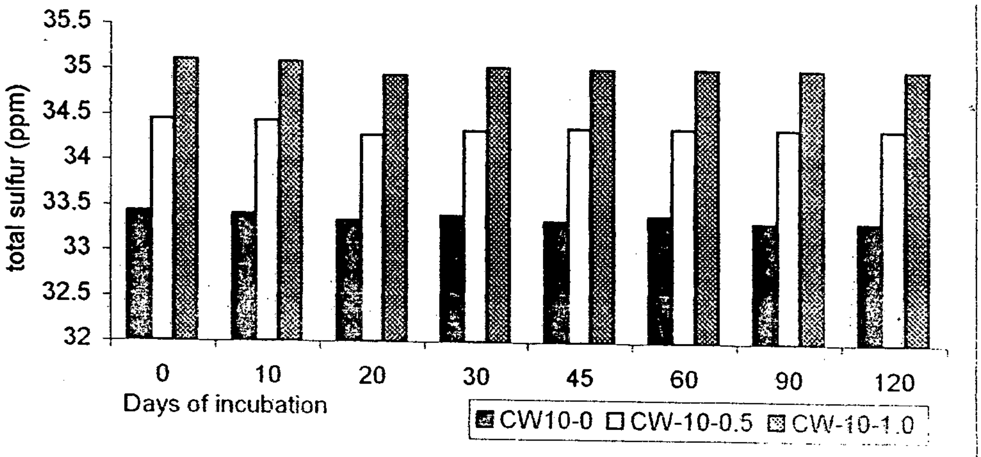

Graph 7.3
total sulfur (ppm)
70
69.5
69
68.5
68
67.5
0
10
20
30
45
60
90
120
Days of incubation
■CM-30-0 □CM-30-0.5 ▨CM-30-1.0


Graph 7.4

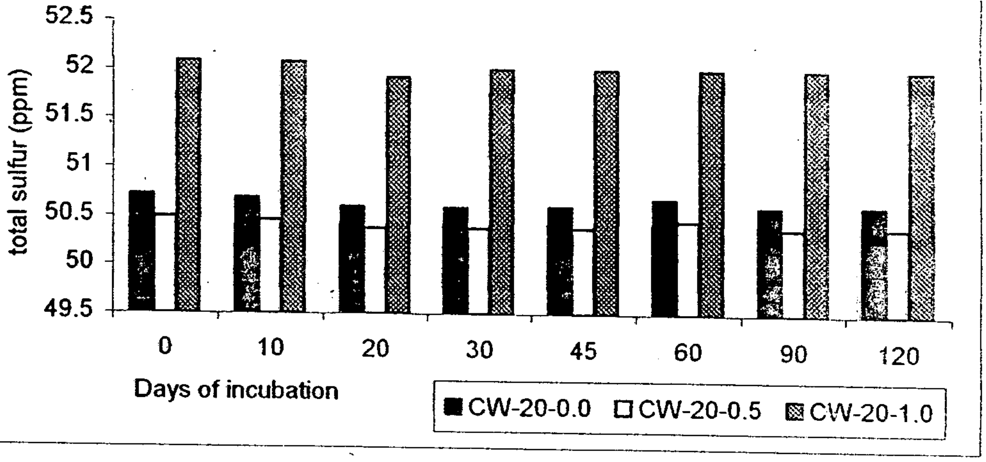

Graph 7.5


Graph 7.6

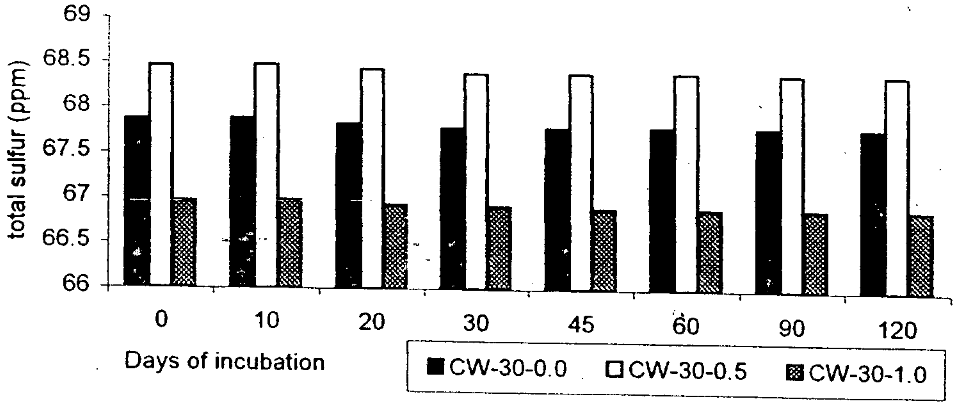
Graph 7.7

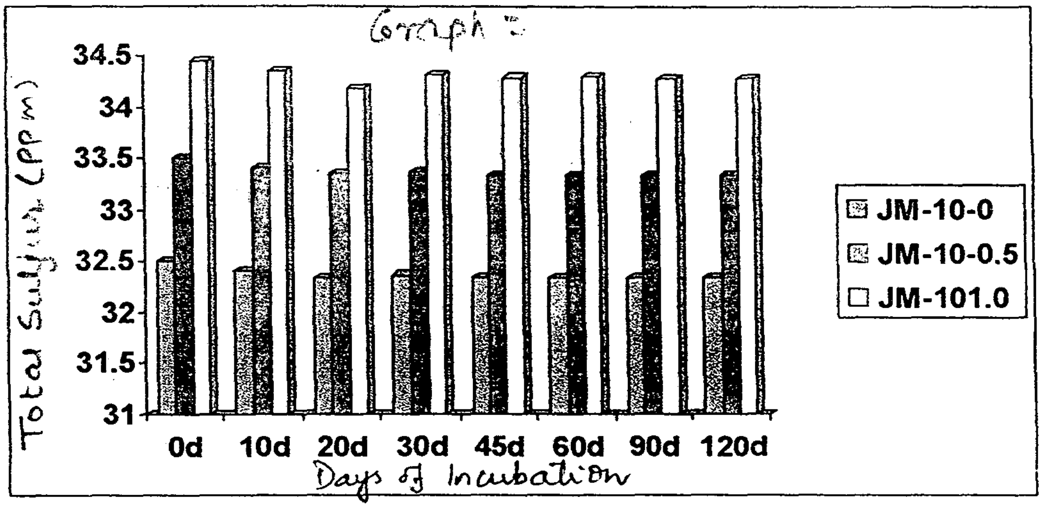


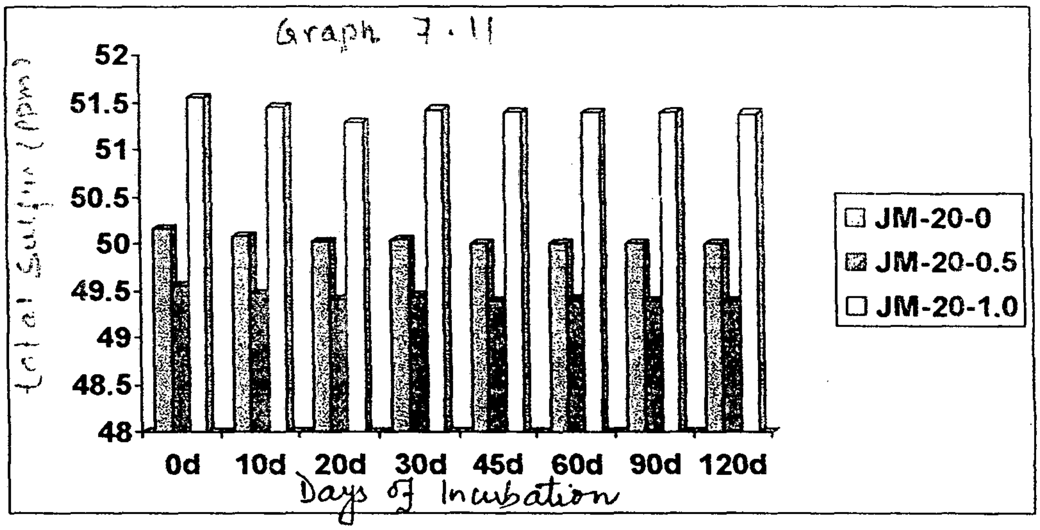
Graph 7.8

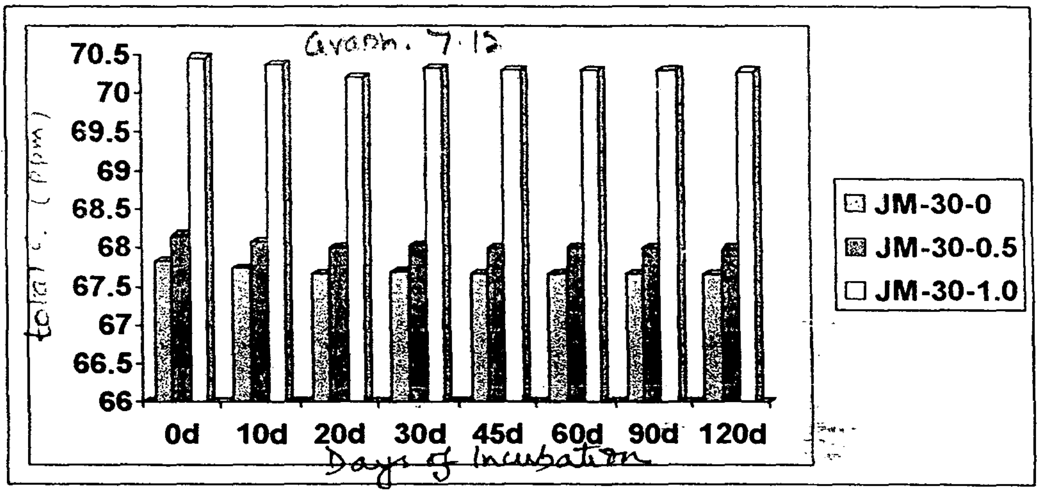


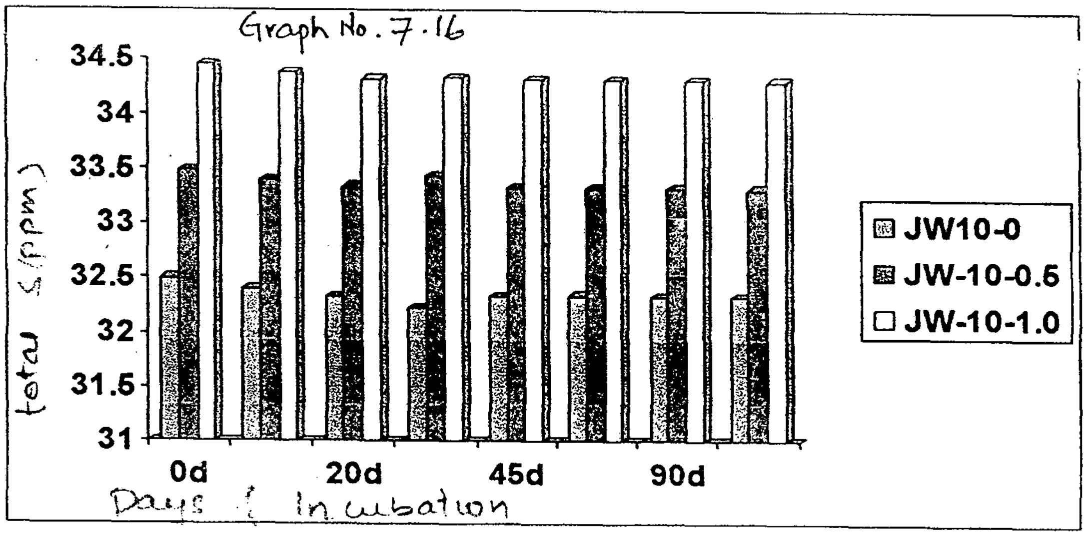
Graph 7.9

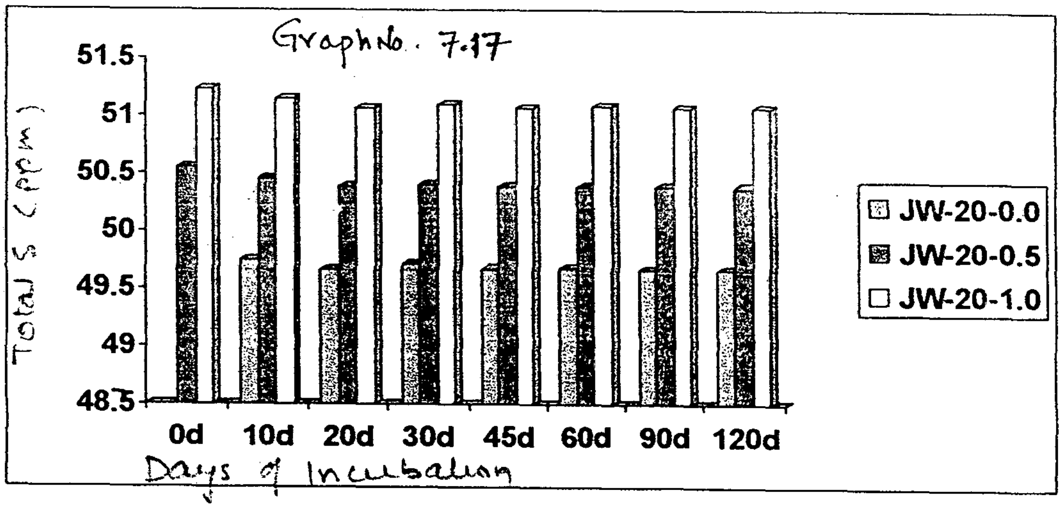


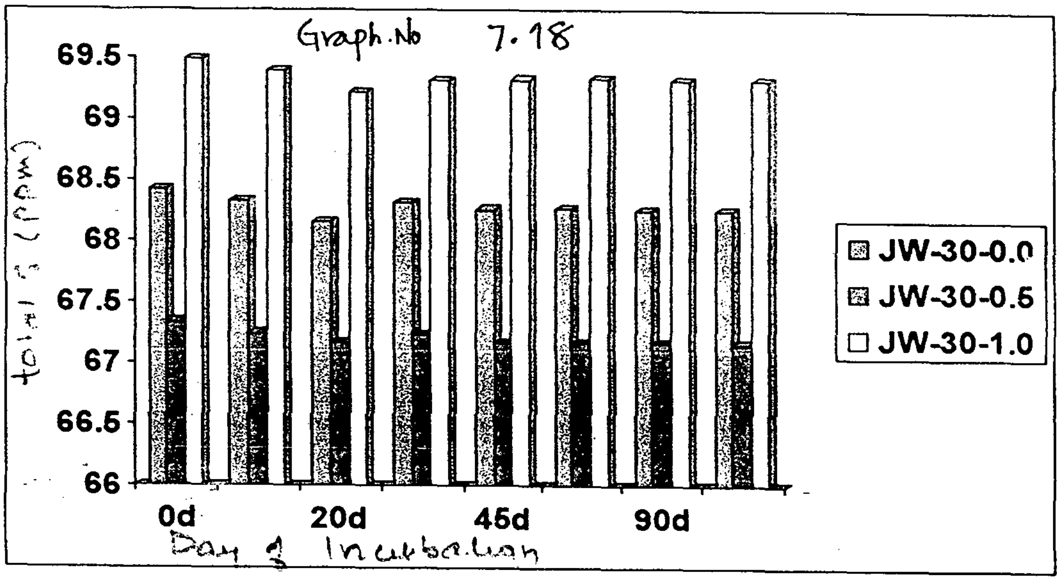

Graph
Total Sulfur (ppm)
34.5
34
33.5
33
32.5
32
31.5
31
0d
10d
20d
30d
45d
60d
90d
120d
Days of Incubation
▨ JM-10-0
▨ JM-10-0.5
☐ JM-101.0

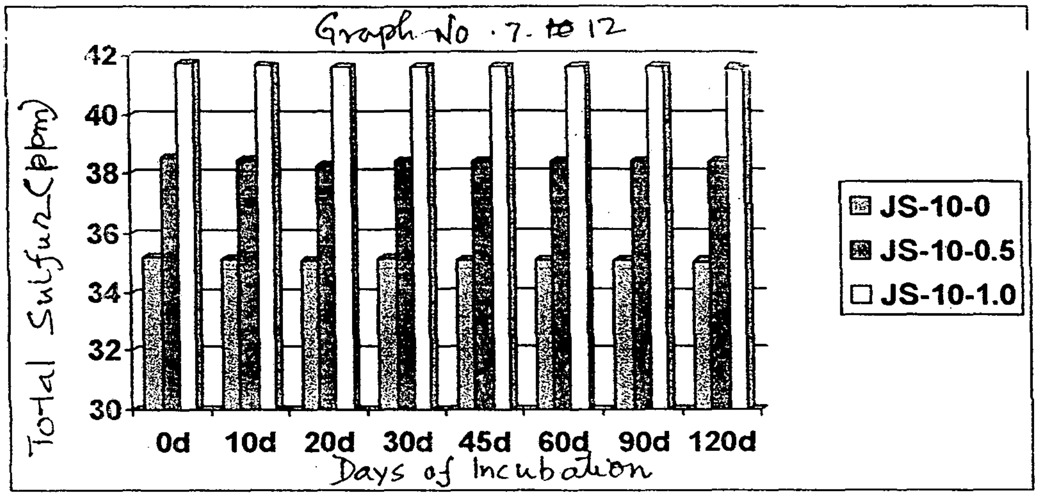

Graph 7.11
total Sulfur (ppm)
52
51.5
51
50.5
50
49.5
49
48.5
48
0d
10d
20d
30d
45d
60d
90d
120d
Days of Incubation
☐ JM-20-0
▨ JM-20-0.5
☐ JM-20-1.0


Graph. 7.12
total (ppm)
70.5
70
69.5
69
68.5
68
67.5
67
66.5
66
0d
10d
20d
30d
45d
60d
90d
120d
Days of Incubation
☐ JM-30-0
▨ JM-30-0.5
☐ JM-30-1.0

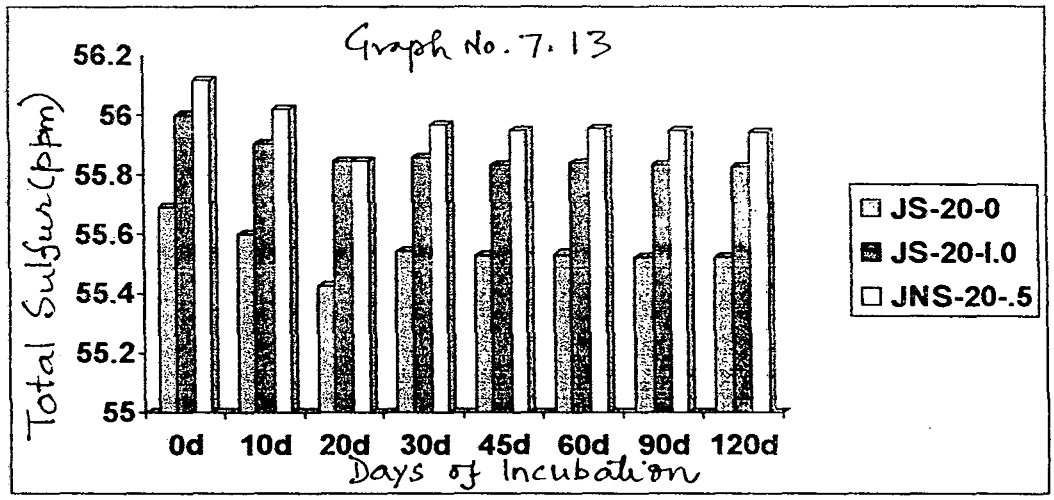

Graph No. 7.16


Graph No. 7.17

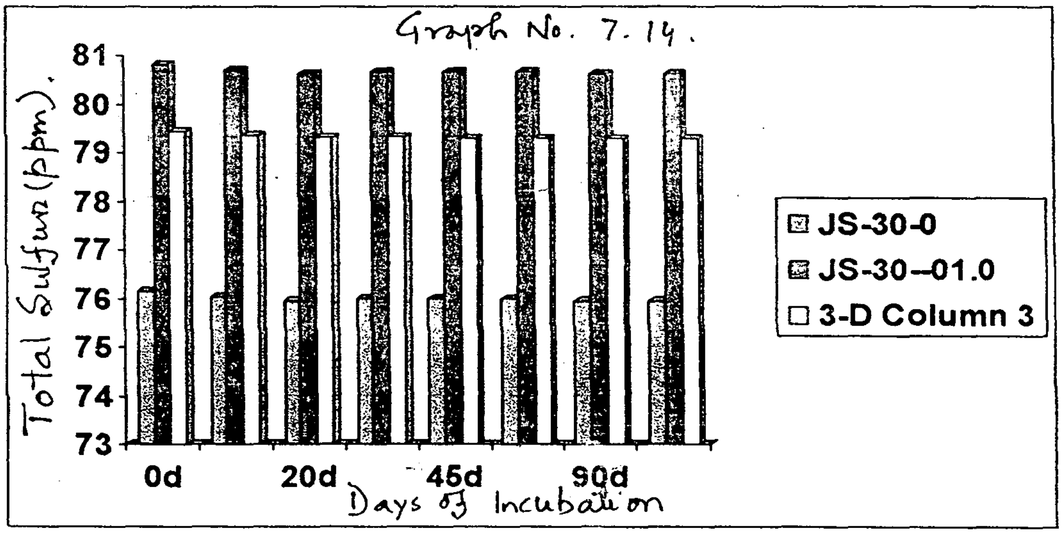

Graph No 7.18



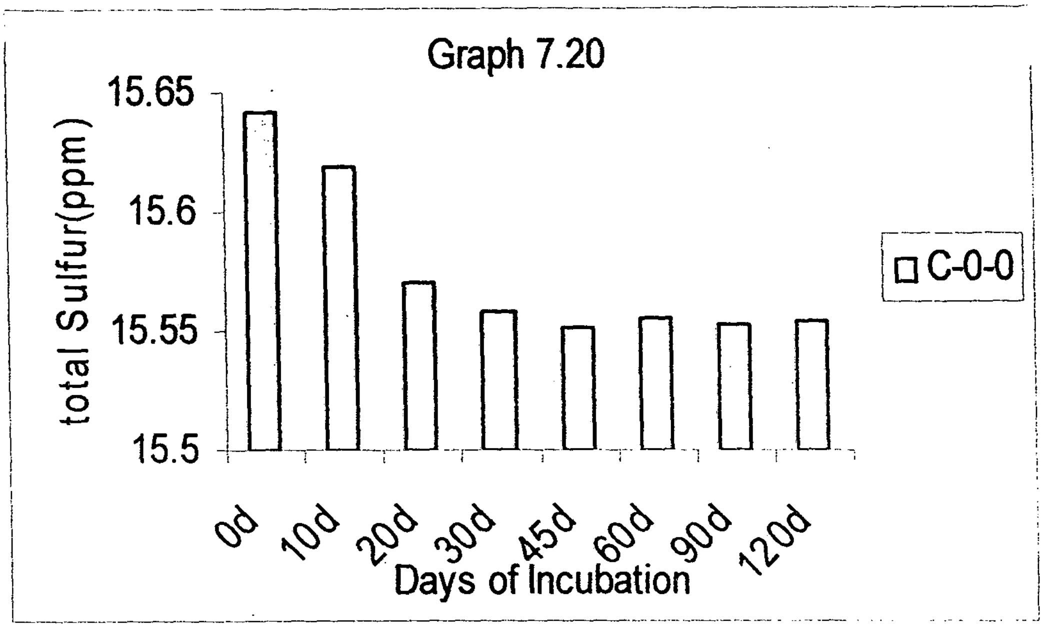
Graph No. 7. ~~to~~ 12

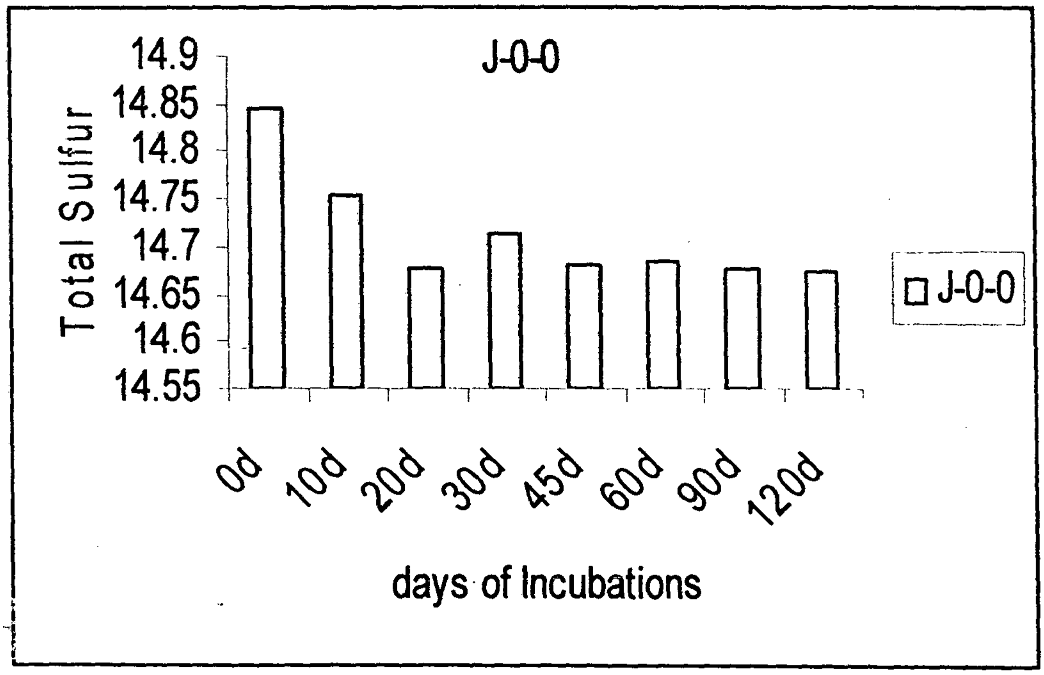


Graph No. 7.13



Graph No. 7.14.


Graph 7.20
total Sulfur(ppm)
15.65
15.6
15.55
15.5
0d
10d
20d
30d
45d
60d
90d
120d
Days of Incubation
□ C-0-0


J-0-0
Total Sulfur
14.9
14.85
14.8
14.75
14.7
14.65
14.6
14.55
0d
10d
20d
30d
45d
60d
90d
120d
days of Incubations
□ J-0-0

Chapter V

Summary & Conclusions

SUMMARY

The characteristics features of the different Physico-chemical properties of the the two soils are summarized as below:

pH

It was observed that when the soils (both soils JNU and Chhattarpur) are amended with wastes, there is a decrease in the pH of the system owing to the highly acidic nature of the wastes. However, when both JNU and Chhattarpur soils were amended with lime treated waste, the pH values of the soil system, amended with lime treated waste, are higher then those amended without lime treatment. In monsoon waste amended soil, when overall maximum variation of three lime treatments were considered, it was observed that pH values decrease with the increase in amount of waste, i.e. when the amended Chhattarpur and JNU soils systems subjected to incubation of 120 days, 10% waste amended soils showed overall maximum variation and 30% waste amended soils showed overall minimum variations when the all the of the three lime treatments were considered. The overall pH value for 10%, 20% and 30% waste amended Chhattarpur soil changed by a multiple of 0.99, 0.97 and 0.96 after the end of incubation period. Corresponding values for10%, 20 % and 30% waste amended JNU soil are 1.05,1.03,1.02 respectively.

Similar results were obtained, when JNU soil and Chhattarpur soil were amended with summer waste and kept for incubation of 120 days. The overall pH values tend to decrease with increase in the percentage of waste after 120 days. The overall pH values for 10%, 20 % and 30% waste amended Chhattarpur soil change by a multiple of *0.98, 0.97, 0.96* respectively after the end of incubation period. Corresponding values for10%, 20% and 30% waste amended JNU soil are *1.02, 0.99, 0.95* respectively.

In winter waste amended soil maximum variation in overall pH values were observed in case of 10% waste amended Chhattarpur soil (by a multiple of0.96)as well as 30% waste amended JNU soil (by a multiple of 0.77)) Similarly minimum variation in pH values were observed for 20% waste amendment in both Chhattarpur soil(by a multiple of 0.98) and JNU soil (by a multiple of 1.01).

When the seasonal variation of the soil pH value is considered, in case of waste amended Chhattarpur soil, summer waste shows overall maximum variation and Monsoon waste shows overall minimum variation. Similarly, in case of waste amended JNU soil, winter waste shows overall maximum variation and Monsoon waste shows overall minimum variation. Any soil systems have buffering capacity, which resists any change in the pH. This phenomenon is reflected in our study also. The pH value of the both amended soils returns towards neutral after the incubation period. Overall percentage change in the pH value after the completion of incubation period (120 days) was in the range of (negative) 4.29% (i.e a decrease of 4.29 % in the pH value have been observed) to 0.72% (an increase by 0.72 % have been observed) for Chhattarpur soil and for JNU soils the corresponding figures were (negative) 6.83% to 6.09%.

ELECTRICAL CONDUCTIVITY

The electrical conductivity (EC) value of both soil of JNU and Chhattarpur, increases with increase in percentage of lime treated waste, however, with days of incubation, the EC decrease~~s~~d.

In monsoon waste amended soil, maximum variation in EC values were observed in case of 20% for Chhattarpur soil (by a multiple of 0.47 and for JNU soils 30% showed maximum variation (by a multiple of 0.72), when all the three lime treatments were considered. Similarly minimum variation was observed for 10% waste amendment in both Chhattarpur (by a multiple of 0.66) and JNU soil (by a multiple of 0.78).

In summer waste amended soil maximum variation in overall EC values considering three lime treatment, were observed, in case of 20% waste amendment for Chhattarpur soil (by a multiple of 0.59) and for JNU soils 10% showed maximum variation (by a multiple of 1.02). Similarly, minimum variations in EC values were observed for 30% waste amendment for both Chhattarpur soil (by a multiple of 0.87) as well as JNU soil (by a multiple of 0.99).

In winter waste amended soil maximum variation in EC values were observed in case of 10% waste amendment Chhattarpur soil and 30% waste amended JNU soil, showed maximum variation. Similarly minimum variation in EC values was observed for 20% waste amended in case of Chhattarpur soil (by a multiple of 0.52) and in 30% for winter waste amended JNU soils (by a multiple of 0.73). When the seasonal variations of the waste amended soil are considered, in case of waste amended JNU soil, winter waste shows overall maximum variation and summer waste shows overall minimum variation of the EC values. Similarly, in case of waste amended Chhattarpur soil, monsoon waste shows overall maximum variation and summer waste shows overall minimum variation in the EC values. In case of waste amended Chattarpur soil, the variation of the EC value was more than JNU soil. When overall percentage variation in the EC values of waste amended soils were considered after the completion of incubation period (120 days), the overall change in the values of EC was from (negative i.e. a decrease) 63% to 41% for Chhattarpur soil and –37.41% (negative i.e. decrease) to 11.04% for JNU soils.

ORGANIC CARBON

The organic carbon of the amended soils increases with increase in percentage of waste and it decreases with the days of incubation. In monsoon waste amended soil, when overall variation over three lime treatments were observed, 30% waste amendment for Chhattarpur soil (by a multiple of 0.64) and 20% waste amendment for JNU soil (by a multiple of 0.77) showed maximum variation in the values of organic carbon after completion of incubation period of 120 days. Similarly minimum variations were observed for 20% waste amended Chhattarpur soil (by a multiple of 0.84) and in 30% monsoon waste amended JNU soils by a multiple of 0.86) All the above conclusion were drawn by considering, all the three lime treatments.

In summer waste amended soils, when overall variation over three lime treatments, were observed, in case of 10% waste amended Chhattarpur soil (by a multiple of 0.73) as well as JNU soils(by a multiple of 0.81), maximum variations were observed. Similarly minimum variations were observed for 30% waste amended Chhattarpur soil (by a multiple of 0.78) and in 20% summer waste amended JNU soils (by a multiple of 0.87)

In winter waste amended soil, when total variations of organic carbon over three lime treatments, were observed, 20% waste amendment of Chhattarpur soil(by a multiple of 0.79) as well as 10 % of waste amendment of JNU soils showed maximum variations from variations (by a multiple of 0.78). Similarly minimum variation was observed in 30% winter waste amendments in both Chhattarpur (by a multiple of 0.84) and JNU (by a multiple of 0.91) soil.

When the seasonal variation of the soil organic carbons is considered, in both waste amended soil, (Chhattarpur soil as well as JNU) monsoon waste shows overall maximum variation and winter waste shows overall minimum variation of organic in both case. In case of waste amended Chattarpur soil, the variation of the organic carbon value was more than JNU soil. Liming doesn't show much significant effect when in case of organic carbon in both soils. The overall percent of Organic Carbon has decreased with incubation period, is in the range of 11.47% to 36.21% for Chhattarpur soil and 2.53% to 36.17% for JNU soil.

CATION EXCHANGE CAPACITY

Cation Exchange capacity (CEC) of the soil system increases, with increase in percentage of waste for both soils i.e. JNU and Chhattarpur. Liming has a significant effect on soil CEC. The addition of 0.5% lime to waste, the CEC values of the soil system usually show a positive trend. However when 0.5% and 1.0% lime treated waste-soil mixture are compared, it has been observed that further addition of 0.5% of lime decreases the CEC (except, 10% waste as well as 20% waste amended JNU soil where an increase has been observed.). For Chhattarpur soil, CEC showed an increase with increase in lime treatment

For monsoon waste amended soils, maximum variation in the CEC value, considering all the three lime treatments, were observed in case of 20% waste amended Chhattarpur soil (changes by a multiple of 0.83) and for 10% JNU soil have showed maximum variation (changes by a multiple of 1.22) in CEC value after the completion of incubation period of 120 days. Similarly minimum variation was observed in 10% waste amended Chhattarpur soil (changes by a multiple of 0.92) and in 30 % waste amended JNU soil (changes by a multiple of 0.93) at the end of incubation period.

In summer waste amended soil, when overall change in CEC of soil-waste system CEC was considered over the three lime treatments, maximum variation were observed in case of 30% waste amendment of the soil of Chhattarpur(changes by a multiple of 0.65) and for10% waste amended JNU soil showed maximum variation (changes by a multiple of 1.18). Similarly minimum variation was observed for in case of 20% waste amended both Chhattarpur (changes by a multiple of 0.85) as well as JNU (changes by a multiple of 0.91) soil.

Maximum variations were observed in case of 30% winter waste amended Chhattarpur soil (changes by a multiple of 0.75) and for JNU soil (changes by a multiple of 0.84) when all the three lime treatment were considered. Similarly minimum variations were observed in case of 20% waste amended Chhattarpur soil. (Changes by a multiple of 0.97) and in 10% waste amended JNU soils (changes by a multiple of 1.02).

When the seasonal variations of the waste amended soil are considered, in case of waste amended JNU soil, winter waste shows overall maximum variation and summer waste shows overall minimum variation of the CEC values. Similarly, in case of waste amended Chhattarpur soil, summer waste shows overall maximum variation and monsoon waste shows overall minimum variation in the CEC values. Overall, waste treated Chattarpur soil showed higher variation of the CEC than JNU soil. The overall percentage change in the CEC value after the Incuabtion period of 120 Days was in the range of 0.91% to 26.76% when compared to the values at 0th day.

AVAILBLE SULFATE

When overall changes in available sulfate of both soils JNU and Chhattarpur were considered, it was observed that available sulfate increased with increase in the percentage of wastes. Available sulfate is dependent upon pH, hence liming of the waste shows significant effect, available sulfate in soil. Liming is also found to facilitate the release of sulfate in available form. With increase in percentage of lime treatment, available sulfate increases. When subjected to incubate, there is an increase in available form of sulfate with days of incubation and it attains stable conditions between 45-60 days of incubation period.

In monsoon waste amended soil, when overall maximum variation over three lime treatments were considered, it was observed that the available sulfur decreases with the increase in amount of waste, i.e. when the waste amended Chhattarpur and JNU soil subjected to incubate till 120 days, 10% waste amended soils showed overall maximum variation (by a multiple of 2.94 and 2.25 respectively) and 30% waste amended soil (by a multiple of 1.60 and 1.08 respectively) showed overall minimum variations. When JNU soil and Chhattarpur soils were amended with summer waste and kept for incubation of 120 days, similar pattern of available sulfate is observed.

Winter waste amended Chhattarpur soil showed similar results. However, for JNU soil, maximum variation was obtained in case of 10% waste amendment (by a multiple of 2.47) and minimum variation was obtained for 20% of waste amended soil (by a multiple of 1.76). The overall percent increase in the value of available sulfate after the completion of incubation period is in the range of 30.29% to 258.73% for Chhattarpur soil and 40.38% to 229.88% for JNU soil.

When the seasonal variation of the available sulfate is considered, in case of monsoon waste amended Chhattarpur as well as JNU soil, show overall minimum variation. Maximum variation was observed in case of winter waste amended JNU soil as well as Chhattarpur soil. However JNU soil releases more sulfate than Chhattarpur soil when an incubation period of 120 days is considered. Since the Chhattarpur soil contains higher amount of soil clay particle, the release of sulfate in soil solution is much slower.

TOTAL SULFATE

When changes in total sulfate of both soils i.e JNU and Chhattarpur were considered, it was observed that total sulfate increased with increase in the percentage of waste. Liming is also found to facilitate the transformation of sulfur from other form to sulfate form.

In monsoon waste amended soil maximum variation were observed in case of 20% waste amendment for Chhattarpur soil (by a multiple of 1.26). as well as 10% waste amended JNU soil (by a multiple of 2.24).. Similarly, minimum variation was observed for 10% waste amended (by a multiple of 1.07). Chhattarpur soil and in 30% waste amended JNU soil (by a multiple of 1.73).

In summer waste amended Chhattarpur soil, the percentage change in overall total sulfate value decreases with increase in the amount of waste. However for JNU soil maximum increase was observed for 20% waste amendment (by a multiple of 3.43) and minimum variation was observed in case of 30% waste amended soil (by a multiple of 1.82).

In monsoon waste amended soil, when overall maximum variation over three lime treatments were considered, it was observed that overall total sulfate decreases with the increase in amount of waste, i.e. when the Chhattarpur soil and JNU soil subjected to incubate for 120 days, 10% waste amended soil showed overall maximum variation (by a multiple of 1.76,1.98 respectively) and 30% waste amended soils showed overall minimum variations (by a multiple of 1.37, 0.98 respectively)

Upon incubation, the Total sulfate of the soil waste system increases and attains stable condition in between 45-60 days of incubation. When the seasonal variation of the total sulfate is considered, in case of waste amended Chhattarpur as well as JNU soil, monsoon waste shows overall minimum variation. Maximum variation was observed in case of winter waste amended JNU soil as well as Chhattarpur soil However in case of JNU soil better mineralization of organic sulfur as well as oxidation of sulfur from other forms to Sulfate form have taken place. The overall percent increase in the value of total sulfate after the completion of incubation period, is in the range of 6.61-122 % for Chhattarpur soil and 42.7-327.59% for JNU soil.

Sulfate adsorption is dependent upon the pH of the soil as well as the organic carbon. Increase in pH causes release of adsorbed sulfate on the soil clay particles. i.e. at higher pH little amount of sulfate is adsorbed . But here in contrast, even at higher pH considerable amount of sulfate was found to be adsorbed. This can be attributed to high Fe content of the waste.

TOTAL SULFUR

Chhattarpur soil has higher total sulfur than JNU soil. The Total sulfur of both the soil increases almost proportionately with increase in the percentages of waste. The increase is found to be maximum for summer waste and minimum for monsoon waste for Chhattarpur soil However when the JNU soil is mixed with waste, the increase is found to be maximum for summer waste and the winter waste showed the minimum increase.

The total sulfur of either JNU soil or Chhattarpur soil showed no significant change from the original value. It showed slight decrease from the initial concentration towards 45-60 days after which it attains a stable value (Table 5.7.1 and table 5.7.2).

CONCLUSION

So from the present study it is clear that the wastes contain high organic carbon, and sulfur content. The sulfate remains adsorbed to the soil clay particle and is released over the time. Hence it may be applied to sulfur deficient soil, where the slow release of sulfate ion over time is required. The sulfate ion also plays an important role in the buffering capacity of the soil as well as in the release of various cations. Hence the amendment of the soil with pretreated waste may releases various cations so that they are easily available to plants.

Hence, it was the purpose of study to find out the proper ecofriendly use of wastes. Dumping is not a solution. The waste should be disposed of in proper way taking into consideration of both the beneficial sides of ecology and economy. Our experimental design has shown us that 10% waste with 0.5% lime treatment will give us better results. We are getting good results of each parameter within 30 days of incubation-60 days of incubation.

However present incubation study is not sufficient to prove the success of waste disposal in all types of soil. Hence there is a need of extending of this study to field experiment including the other parameters to see the practical applicability. In this way hazardous solid waste can be used for beneficial process.

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