RAINWATER POLLUTION MODELLING OF AN INDUSTRIAL CITY; (A CASE STUDY OF DELTA STATE OF NIGERIA)

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BEING A PARTIAL FULFILMENT FOR THE AWARD
OF B.ENG IN DEPARTMENT OF CHEMICAL
ENGINEERING
OF FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
NIGER STATE - NIGERIA.

MARCH 2000

ABSTRACT.

Experimental analyses of rainwater due to gas flaring in Delta state of Nigeria have being carried out. The pollution of the rainwater has been modelled mathematically using the q basic, programme. It was observed that the model and experimental results were in conformity. The pollutants were observed at maximum at distance of between 1,500m to 2,500m from the monitored stations, while less than 1,000m are almost free from the pollutant, when the stack height was 10m. The quality of the pollutant with respect to the physico-chemical parameter of their rainwater such as PH is unacceptable to World Health Organisation and Federal Environment Protection Agency Standards.

3. To predict the behaviour of rainwater at any given circumstances.
4. To identify the effect of polluted rainwater on the environment & ecosystem.
5. To put in place the necessary control measures of the pollution.

1.20 JUSTIFICATION OF STUDY:

This study is carried out for the purpose of understanding the environmental problems affecting industrial areas of Delta State and aquatic life. This particular aspect will be intensively covered in the results and discussion of results.

Recommendation will be made on the ways of improving the situation and conclusion will be drawn.

1.30 SCOPE OF STUDY:

This work focuses on the environmental condition in the industrial area of Delta state for the months of October'97 to September'98 and is limited to one gas plant and two flow stations.

CHAPTER TWO

2.0 LITRATURE REVIEW:

2.10 ENVIRONMENTAL POLLUTION:

The Macmillan dictionary of the environment defines environment as the physical, chemical and biotic condition surrounding a living organism, and pollution as the direct or indirect alteration of the physical, thermal, biological or radio active properties of any part of the environment in such a way as to create a hazard or potential hazard to health, safety or welfare of any living species. Pollution may occur naturally, but the term is more commonly applied to changes brought by the emission of industrial pollutant or by the careless discharge or disposal of human domestic waste or sewage. The terms also include the production of excessive noise (e.g. by air craft, read vehicles or factories) and the release of excessive heat.

Pollution is undoubtedly destructive and capable of leading to dealt of living beings, plants inclusive. It is also capable of disturbing the environment to the extent of rendering it unusable to human beings and hence curtailing the immense benefits which human being could gain from the environment.

Although industrialization is highly desirable for the sustenance of a nations economy and the improvement of the well of its citizenry, the negative impacts precipitated by the introduction of its unwanted by-products into the environment may be catastrophic if allowed to build up and unattended to.

Environmental issues have always had some place in human affairs all the whole process of human history has been working with nature and natural resources. While the population explosion have made it a critical one The past decade has witnessed a growing concerned on the part of public authorities and the public at

2.4.1 AIR POLLUTION.

2.4.1.1 AIR POLLUTION AND THEIR SOURCE.

Five major classes of pollutants are discharged into the air, i.e. carbon monoxide (CO), particulates, Sulphur oxides (SO_x), Hydrocarbon (HC), and Nitrogen oxides (NO_x), constitute gaseous pollutant in the air.

The major sources are from combustion of fuel in electric-power plant, industrial processes, space heating and as natural gas or dissolved gas in crude petroleum.

2.4.1.2 HYDROCARBON EMMISSION.

Below are the sources of hydrocarbon.

1. Vents, drains flanges on equipments, column and lines.
2. Through evaporations at waste treatment units.
3. Through sampling points.
4. Through releases via pressure safely valve to the flares.
5. During loading and unloading operations.

2.4.1.3 NOISE.

Sources of noise.

1. Impacts e.g. hammer, gear noise, drill noise etc.
2. Out of balance force.
3. Stickler slip friction e.g. brake squeal from horning processes.
4. Magnetostostrictive effect e.g. transformers or motor

5. Hydraulic noise e.g. noise form hydraulic power unit.
6. Aerodynamic and pneumatic noise.

2.4.2 WATER POLLUTION.

The industrial wastewaters are the major sources of water pollution. In industrial settlements where pollutants gases are discharge to the atmosphere during processing, these pollutant gases find their ways into surface water or rain water these by polluting the water. 7.

Major pollutant found in waste water include the following:

1. Heavy metals – pb, Ni, Cd, Zn, Cn, and Hg.
2. Natural organics – Phenols, formaldehyde.
3. Synthetic organics – pesticides, Herbicides, Detergents.
4. Inorganic – Ammonia, Cyanide, fluorides, Nitrites, and sulphates.

2.4.2.1 ACID RAIN.

All rainfall is by nature somewhat acidic. Decomposing organic matter, the movement of the Sea, Volcanic eruptions and acidic oxide gases discharge from industries all contribute to the accumulation of acidic chemical in the atmosphere, but the principal factor is atmospheric carbon dioxide (CO_2), which cause a slightly acidic rainfall (PH of 5.6).

There is no doubt that man-made pollutant accelerates the acidification of rainfall. Man-made emissions of sulphur dioxides (SO_2) and Nitrogen oxides (NO_x)

damage man-made materials such as those used in construction and sculpture. Building material too can be degraded by acidity. For example limestone, marble, carbonate base points, and galvanised steel all can be eroded.

Acid rain may also affect human health when it mobilises toxic trace metals such as aluminium and mercury, when dissolved in water, fish and animals can ingest these material, building as in human food chain. Acid water could also leach lead (pb) out of pipe and into drinking water supply.

Some of the possible environmental effect of acid rain are: Excessive leaching of nutrients from plant foliage and soil, disturbance of balance of predators and prey in aquatic ecosystem various metabolic disturbance to organism, acidification of lakes and streams and the corrosion of structures.

2.5.1 EFFECT OF INDUSTRIAL POLLUTION.

Pollution could cause many effects, some of which are immediate and obvious (sore, eyes, difficult, breathing, neurotic vegetation) and nearly all of which could result in chronic degradation of man and his resources under specific condition.

The net effect of pollution on man can be said to be economic and or time effects. The economic effect is direct and indirect cost of controlling pollution. The immediate cost of providing pollution controls is an economical burden, but pollution control cost can be received back sometimes, with a profit return. The time consideration implies length of life, but it is also known that some pollutants are beneficial while others may be detrimental to life (DIX H.)

2.5.2 EFFECT ON HEALTH.

It is obvious that pure air play an important role in the preservation of health. A polluted environment does not provide the right condition for a definite rest;

relaxation and recreation. In other to eliminate the harmful effects of air pollution, the organism combines energy, which mean an unnecessary stress and the resistance of the organism decreases. Polluted air weakens the organism thus ensuring illnesses, aggravating already existing ones and retarding recovery.

Short lasting pollution of high concentration, cause acute illnesses. This kind of pollution acts selectively. It affects the more sensitive individuals and those already ill, even killing them. Chronic pollution however, exerts its effects during the entire life of the individual, on each individual of the population on several generations.

The lasting effect may change metabolic processes, causing chronic illnesses, and even genetic aberration. According to a large assessment by Dean (1968) city air pollution increases mortally rate caused by chronics bronchitis and hug cancer. If air pollution and smoking were eliminated we says morality caused either by lung cancer or chronic bronchitis could be reduced to one tooth and to one and half of the present value, respectively. The member of cancer causes affecting the recuperating system has been increasing all over the world. Air pollution is suspected to be its cause due to the fact that combustion products contain large amounts of different polycyclic aromatic hydrocarbon, which are carcinogenic.

Pollutant may attack the lung, though five main sites of action or mechanism.

1. In the respiratory system, which reaction by the initiation of constructive action of the bronchi reflex.
2. The blood vessels of the bronchia and its branches which try to reduce the absorption of harmful substances through the bronchial mucosa.
3. In the blood vessels of the lungs, where they react by decreasing absorption from the alveolar (Pulmonary) capillaries.

4. By penetration into organs, tissues or cells and by affecting metabolic processes.

There are four general areas into which pollution effect can be classified include.

1. Effect on vegetation.
2. Physiological effect on man and other animals
3. Material effect
4. Water quality.

Excessive pollution can cause plants and crops to be bleached, discoloured and stunted. Small amount of pollution can equally increase growth rate. Estimate of cost due to excessive pollution damage in the united state vary from $4 to $20 billion per year (DIX, H.M). No income cost is made for beneficiation of plant by pollution on for secondary effects to poisoning of animal that eat poisoned plants.

Superficial physiological damage to man and other occurs, in the form of irritation of the eyes, skin upper respiratory tract, stomach (nausea) and surmise (allergy). Industrial pollutants as a whole can literally affect part of the body tissue and organism promoting emphysema and overburdening the heart people who are incapacitated because of industrial pollution and smoke inflicted illness, such as the incurable emphysema may not be able to work and earn wages.

2.6 POLLUTION CONTROL.

Pollution of water, air atmosphere, etc means to make them dirty, impure and dangerous for people and animals to live in or to use. This can be by means of poisonous chemical. Therefore pollution can make human and animals existence very unbearable if not controlled.

The most effective means of dealing with the problem of pollution is to prevent the formation of the pollutant or minimise their emission at the source itself. In the case of industrial pollutants, this can often be achieved by investigating various approaches at an early stage of process design and development and selecting those methods which do not contribute to the pollution or have the minimum pollution potential..

Pollutant control at the source can be accomplished in several ways.

i Operational changes

ii Modification or replacement of process equipment.

iii Row material charges.

iv More effective operation of existing equipment.

2.6.1 ADVANCES IN HAZAROUS AIR POLLUTANT PURIFICATION TECNIQUES.

Most of the advances in hazardous air pollutant control or purification techniques are based on existing technologies used in other processes. The viability of any technique depends on the specific details of the emission site-specific constraints, regulatory concerns and economic consideration.

Known techniques/technologies now being used or adopted for hazardous air pollutant control measure include bio filtration, modification and development of new adsorbents to replace the commonly used carbon, thermal and catalytic incineration. Recent modification and improvements on most techniques, especially in their process operation have significantly enhanced their control efficiency, extended their range of applicability and enhanced their economic feasibility.

2.6.2 ECONOMICS OF INDUSTRIAL POLLUTION.

The extent to which gas cleaning (industrial) it is carried out, and the type of plant selected, is a question of plant economics, process economics and the community economics.

If we consider the simplest case, in which the waste gases produced by a process do not cause harm, and are there fore not pollutants, but contain a valuable ingredient, the optimum recovery is that which produce the amount of ingredient with the effective minimum cost. However, if the ingredient is harmful even in small quantities, then recovery must be such that the maximum concentration allowable in the exit gases is not exceeded. Even if the ingredient does not do harm, an arbitrary maximum may be set by an outside organisation, such as a government body.

These arbitrary level are set because of lack of adequate knowledge of the factors making up what can be called the "net social cost" equation. This simplest term is expressed as follows.

N.S.C - Damage cost to no control - Redaction in damage with control equipment - cast of control equipment.

We therefore realise the tremendous difficulties involved in assessing the damage caused by pollution; while the health cost may be estimated in some ways and damage or property by corrosion and sorting may also have a monetary value, loss of visibility or aesthetic losses are impossible to asses financially simultaneously, the reduce damage which occurs with the installation of control is not generally assessable. The last term of the NSC equation, the cost of control/ (which include any profit from by product sales) is however assessable, and is of greatest interest to those initially gas cleaning or other pollution control equipment.

CHAPTER THREE.

3.0 MATHEMATICAL MODELLING OF VARIOUS COMPOUNDS. CONCENTRATION IN RAINWATER FROM GAS FLARING.

ASSUMPTIONS.:

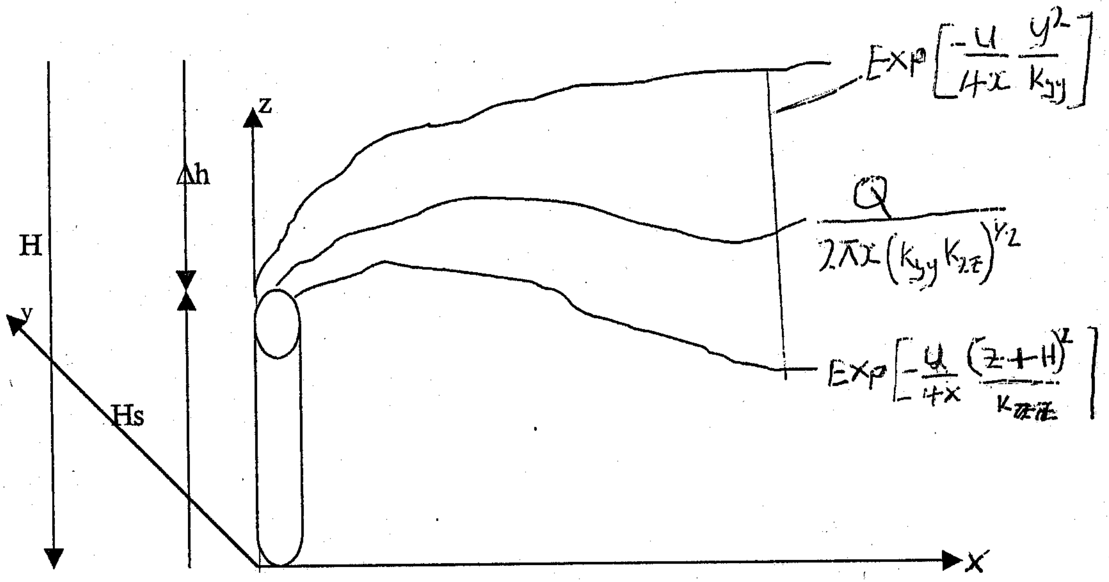
1 The gas mixture is of constant density.

2 Pollutant (flare gases) is chemically inert.

3 Eddy diffusivities are constant throughout the space (stationary homogeneous turbulence).

4 Turning of wind due to frictional effect is neglected.

5 At the point where the plume hints the ground, it is assumed that the pollutant reflected upwards i.e. consideration of any absorption or deposition of pollutant when the plume reaches the ground is neglected.



Where

Ū = wind velocity (m/s)

Y = distance (m)

K_{xx}, k_{yy}, k_{zz} = Eddy diffusivities (m^2/s)

H = Effective height ($H = hs + \Delta h$) (m)

Q = Quantity of gas flare (g/s)

Concentration Cι of flared gas at distance from the source

$$C_\iota = \frac{Q}{2\Pi x(k_{yy}, k_{zz})^{½}} \exp\left[\frac{-\bar{U}}{4x}\,\frac{y^2}{k_{yy}}\right] \exp\left[\frac{-\bar{U}}{4x}\,\frac{(Z+H)^2}{k_{zz}}\right] \quad \ldots\ldots\ldots\ 1$$

From assumption (v) z = 0

$$C_\iota = \frac{Q}{2\Pi x(k_{yy}, k_{zz})^{½}} \exp\left[\frac{-\bar{U}}{4x}\,\frac{y^2}{k_{yy}}\right] \exp\left[\frac{-\bar{U}}{4x}\,\frac{H^2}{k_{zz}}\right] \quad \ldots\ldots\ldots\ 2$$

$$\text{But } б^2_y = \frac{2K_{yy}x}{\bar{U}} \quad \ldots\ldots\ldots\ldots\ 3$$

$$Б^2_z = \frac{2k_{zz}x}{\bar{U}} \quad \ldots\ldots\ldots\ldots\ldots\ 4$$

From evolution of (3) and (4)

$$K_{yy} = \frac{Б^2_y\bar{U}}{2x} \quad \text{and} \quad k_{zz}\ \frac{б^2_z\bar{U}}{2x} \quad \ldots\ldots\ldots\ 5$$

Substitutes (5) into (2)

$$C_\iota = \frac{Q}{2\Pi x\left(\frac{Б^2_z\bar{U}}{2x} \cdot \frac{б^2_y\bar{U}}{2x}\right)^{½}} \exp\left[\frac{-\bar{U}}{4x}\,\frac{y^2}{\frac{б^2_y\bar{U}}{2x}}\right] \exp\left[\frac{-\bar{U}}{4x}\,\frac{H^2}{\frac{б^2_z\bar{U}}{2x}}\right]$$

$$C\iota = \frac{Q}{\Pi б_z б_y \bar{U}} \exp[-½(y/б_y)^2] \exp[-½(\frac{H}{б_z})^2] \quad \ldots\ldots\ldots\ldots\ldots \; 6$$

Concentration in rainwater Cw

$$Cw = \frac{K\,C\iota}{0.1x}$$

$$Cw = \frac{kQ}{0.1x\,\Pi б_z б_y \bar{U}} \exp[-½(y/б_y)^2] \exp[-½(\frac{H}{б_z})^2] \quad \ldots\ldots\ldots\ldots\ldots \; 7$$

K = solubility of component and 0.1xx = view factor

But

$H = hs + \Delta h$

Where

Hs = Height of stack

Δh = plume rise.

$$\Delta h = \frac{Vsd}{\bar{U}} [1.5 + 2.68 \times 10^{-3} pd (\frac{Ts - Ta}{Ta})] c \quad \ldots\ldots\ldots\ldots \; 8$$

Where;

Vs = stack discharge velocity (m/s)

D = stack diameter (m)

$\bar{U}$ = wind speed (m/s)

P = atmospheric pressure (mbars)

Ts = stack discharge temperature (k)

Ta = Ambient temperature (k)

C = Weather condition

C = 1 for neutral

For unstable = 1.15

For very stable condition. = 0.85

CHAPTER FOUR

4.0 EXPERIMENTAL METHODOLOGY:

All the experimental methods carried out in this project research are aimed at analysing and determine the extent of pollution in Delta State and its adjoining area which has been polluted by the gaseous pollutants being discharged from the various gas plants and flow stations in the area. These methods are specifically employed to determine certain physical and chemical characteristic of the rainwater of the industrial area being polluted by the gaseous pollutants discharged from the stations. All the experiments mentioned have been performed by industries situated in the area. The explanations of the experimental methods to enhance understanding of the proposed modelling technique and verify its validity.

4.10 SAMPLE TECHNIQUE.

The aim of sampling before analysis is to obtain a good representation of the bulk, since it is not possible to handle the whole at a time. The samples taken would be as far as possible reflect the character of the bulk needed for the analysis, and are taken at specific distance of 500m, 1,000m and 5,000m from the monitored stations.

4.20 PRESERVATION OF SAMPLES:

Certain chemical changes alter the chemical structure of the constituents of water that are functions of the physical change since not all sample taken were analysed on the very day of collected, they are collected in plastic container and stored in a refrigerator at a temperature of about 4^0C.

4.30 PHYSICAL & CHEMICAL DETERMINATION.

1. PH
2. Temperature
3. Electrical conductivity.
4. Determination of chloride (Cl^-)
5. Determination of sulphate (SO_4^{2-})
6. Determination of Nitrate (NO_x)
7. Determination of Alkalinity
8. Determination of carbonate, Bicarbonate and carbon dioxide.
9. Determination of calcium ion (Ca^{2+}) + magnesium ion (mg^{2+}).
10. Determination of zinc ion ($2n^{2+}$).

4.3.1 INSTRUMENT & EQUIPMENT.

1) PH meter
2. Thermometer
3. Conductivity cell
4. Filter paper
5. Burette
6. Pipette
7. Flask
8. Beaker
9. Glass tubes
10. Weighing scale
11. Test paper indicator

4.3.2 DETERMINATION OF PH

Procedure: Before measuring the PH of the test sample, the electrode was thoroughly washed with distilled water and then with the sample. The temperature control was set to the temperature of the sample and the system was allowed to stabilise the system before the reading was finally made.

The determination was made in unstirred solution to avoid loss of carbon dioxide (CO_2) or other volatile components, which would alter PH value.

Result: PH value was reported to the nearest of PH unit.

4.3.3 DETERMINATION OF TEMPERTURE.

Procedure: The temperature was determined with a thermometer at the time of collection and at the time a particular experiment was to be carried out.

The measurement was made with thermometer immersed directly in the rainwater sample after a period of time sufficient to permit a constant reading.

Result: The temperature was recorded to the nearest 0.1^0

4.3.4 DETERMINATION OF ELECTRICAL CONDUCTIVITY.

Reagent

i) Distilled water of low conductivity for preparing standard solution.

ii) Standard potassium chloride $0.01 mol.1^{-1}$ for the calibration of electrodes 0.7456g of anhydrous kcl (dried at 105^0C) was dissolved in distilled water, and made up to 1000ml at 20^0C.

Procedure: The temperature of the sample is brought near to 20^0C and the conductivity cell is thoroughly rinsed with some of the sample and the tube is then filled to the brim, ensuring that no air bubble adhere to the electrode. Two tubes of the sample are placed in a water bath m maintained at $20^{O}C$ and allowed for 30min to reach thermal equilibrium the size of the tube permit a depth of at least 2cm of liquid below the cell and 2cm above it. The cell is thoroughly rinsed with the first tube and measurement is made in the second tube accordingly.

Calculation: The result is obtained by multiplying the observed conductivity by the call constant. The electrical resistance is indicated on the scale of the apparatus, the electrical resistance in KΩ divides the cell constant.

The instrument does not automatically compensate for temperature difference; the result is divided by the temperature factor [1-0.022(20-t)]. This factor is approximately correct for natural water.

$$E = \frac{C.Em}{[1-0.022(20-t)]} \quad \text{or } E = \frac{C}{Rm} \times \frac{1}{[1-0.022(20-t)]}$$

Where;

E = Electrical conductivity of the sample

C = Cell constant

Em = Electrical conductivity measured ($ms.m^{-1}$)

T = sample temperature

Rm = Electrical resistance measured (KΩm).

4.3.5 DETERMINATION OF CHLORIDE (Cl^{-1}).

SILVER NITRATE METHOD.

Reagents:

1. H_2SO_4 - 0.02M

2. $AgNO_3$ - 0.02M
3. Methyl orange indicator
4. Potassium chromate indicator.

Procedure:

To $100cm^3$ filtered water sample, 2 drops of methyl orange indicator are added and titrated with 0.02M of the H_2SO_4 until the indicator colour changes to orange. 10 drops of potassium chromate indicator are added and titrated with 0.02M $AgNO_3$ solution and mixed gently until yellow colour of the indicator changed to reddish brown tinge. Blank test is carried out on the reagent by repeating the test with $100cm^3$ of distilled water in place of the water sample.

Calculation: If V_1 and V_2 are the volume of silver nitrate solution required by the sample and blank respectively then

$$\text{Concentration } cl^-(mg/l) = \frac{(V_1 - V_2) \times 1000}{\text{Volume of sample (ml).}}$$

4.3.6 DETERMINATION OF SULPHATE (SO_4^{2-})

EDTA TITRIMETRIC METHOD.

Reagents:

1. 0.5M Hcl
2. 0.04M $Bacl_2$
3. 0.2g total hardness indicator
4. 3mls of sulphate butter solution
5. 0.02M EDTA

Procedure:

$10cm^3$ of filtered water sample is pipette into a conical flask and $1cm^3$ of 0.5M Hcl is added using burette and exactly $10cm^3$ of $Bacl_2$ 0.04M solution and well stirred. In a small vessel, 0.2g of total hardness indicator is dissolved in $3cm^3$ of sulphate buffer and the mixture is added to the sample.

O.02M EDTA solution is slowly titrated with the sample and stirred continuously until all traced of red colour disappeared and the indicator changed to blue or grey colour.

Calculation:

$$SO_4^{2-}(mg/l) = \frac{961(V_2 + V_3 - V_4)}{V_1}$$

Where;

V_1 = Volume (ml) of sample,

V_2 = Volume (ml) of $0.01 mol.l^{-1}$ EDTA equivalent to the hardness in V_i (ml) of sample.

V_3 = Volume (ml) of $0.01\ mol.l^{-1}$ $Bacl_2$ added.

V_4 = Volume (ml) of $0.01\ mol.l^{-1}$ EDAT used in the titration of hardness plus excess barium.

4.3.7 DETERMINATION OF NITRATE (NO_x)

Reagents:

1. IM Hcl: One part of concentrated Hcl (12M) was added to eleven parts of distilled water.

2 Nitrate standard: 0.3611g of potassium Nitrate (HR) dried at 1050C in an oven was dissolved in $250cm^2$ at distilled water. The solution of $100cm^3$ was diluted to $1000cm^3$ of distilled water. This final solution contains $2mgl^{-1}$ $NO^{3-}N$.

Procedure:

To $50cm^3$ of filtered water sample, $1cm^3$ of 1M Hcl is added and mixed thoroughly Absorbance of the standard and sample is measured against distilled water blank at 220mm

Silica curette is used for measuring the absorbance. It was corrected for interference from dissolved organic matter by measuring absorbance at 275mm and subtracted twice the reading from the value of at 220mm.

Calibration curve is prepared from the absorbance of a series standard.

4.3.8. DETERMINATION OF ALKALINITY

ELECTROMETRIC TITRATION METHOD.

Reagents:

H_2SO_4 acid, 0.05 or $0.01mol.1^{-1}$

Procedure:

100ml of the sample is placed in a beaker fitted with a magnetic stirrer; a glass rod, a colonel electrode and the tip of the burette are lowered into die sample. The sample is titrated with standard sample to PH of 8.3. The volume of acid used corresponds to the phenolphthalein alkalinity. The electrometric titration is continued to a PH of 4.5. The total titration gave she total alkalinity.

Calculation:

Phenolphthalein alkalinity as $CaCo_3$ ($mmo.1^{-1}$) = 1000 x A x C/V.

Total alkalinity as CaCo3 (mmo.l^{-1}) = 1000 x B x C/V.

Where;

A = ml of standard acid solution to reach the phenolphthalein end point or PH.8.3.

B = ml of standard acid solution to reach the endpoint of methyl orange or mixed indicator or the second end point of electrometric titration.

C = concentration of acid m mol..l^{-1}

V = volume (ml) of sample.

Using 100ml of sample and 0.1mmol.l^{-1} standard acid solutions, the numerical value of alkalinity is directly expressed mmol.l^{-1} by the number of ml of titrant consumed.

4.3.9 DETERMINATION OF CARBONATE, BICARBORNATE AND CARBON DIOXIDE.

The concentration of the three-carbonate species – carbonate, bicarbonate and carbon dioxide are interrelated by chemical equilibrium involving PH.

The concentration of the carbonate, bicarbonate and carbon dioxide are calculated from PH. Total alkalinity, temperature and ionic strength.

Exact mathematical solution:

Theory

The total alkalinity and carbonate alkalinity or phenolphthalein alkalinity expressed in mg/l as $CaCO_3$, are given by the following equations in which the concentration of the various ions are expressed in mol.l^{-1}.

(Total alkalinity) = $[2\{CO_3^{2-}\} + \{HCO_3^-\} + \{OH^-\} - \{H^+\}] \times 50$ ……1

(Carbonate alkalinity) = $[\{CO_2^{2-}\} + \{OH^-\} - \{H_2CO_3^*\} - \{H^+\}] \times 50$ …. 2

4.3.10 DETERMINATION OF CACIUM ION (Ca^{2+}) + MAGNISUM ION (Mg^{2+})

EDTA TITRIMETRIC METHOD..

Reagents:

1. 2M NaoH
2. 0.01M EDTA
3. Sample water

Procedure:

2.0ml of NaoH solution is added to 50ml of sample water or sufficient volume of Naoh that resulted in a pH of 12 – 13. 0.1 – 0.2g of EBT indicator is added. EDTA titrant is added slowly immediately after the addition of the indicator, with continuous stirring to the proper end point. The end point is checked by adding 1 – 2 drops of the titrant in excess to make certain that no further colour charge occurs.

Calculation:

The sum of the calcium and magnesium content, ca + Mg expressed in mill mole per litre is given by the equation

$$C_{ca + Mg} = \frac{C_1 V_3}{V_o}$$

Where C1 = the concentration, expressed in mill moles per litre of the EDTA.

Vo = is the volume mill litre of the test potion (normally 50ml)

V3 = is the volume in mill litre, of the EDTA used in the titration.

CHAPTER FIVE

RESULTS AND DISCUSSION OF RESULTS

able 1 concentration(mg/) of experimental and simulation at various

dis(m)	exp(mg/l)	simu(mg/)
0	0	0
500	1.00E-01	2.04E-04
1000	1.03E+00	3.09E-02
5000	1.80E-01	6.23E-03

1300k

able 2 concentration(mg/l) and distance(m) at various volume at constant temperature of 1300

dist(m)	v=11296.5	v=9000	v=7000	v=5000	v=3000	v=1000
0	0	0	0	0	0	0
1000	3.09E-02	2.46E-02	1.92E-02	1.37E-02	8.21E-03	2.74E-03
2000	5.14E-02	4.10E-02	3.19E-02	2.28E-02	1.37E-02	4.55E-03
3000	2.35E-02	1.87E-02	1.42E-02	1.04E-02	6.23E-03	2.08E-03
4000	1.14E-02	9.10E-03	7.08E-03	5.06E-03	3.03E-03	1.01E-03
5000	6.23E-03	5.00E-03	3.86E-03	2.76E-03	1.66E-03	5.52E-04
6000	3.73E-03	3.00E-03	2.31E-03	1.65E-03	9.91E-04	3.30E-04
7000	2.40E-03	1.90E-03	1.49E-03	1.06E-03	6.37E-04	2.12E-04
8000	1.63E-03	1.30E-03	1.01E-03	7.20E-04	4.32E-04	1.44E-04
9000	1.15E-03	9.20E-04	7.15E-04	5.10E-04	3.06E-04	1.02E-04
10000	8.46E-04	6.74E-04	5.24E-04	3.74E-04	2.25E-04	7.49E-05

able 3 concentration(mg/l) and distance(m) at various temperature at constant volume of 11296.5

dist(m)	T=1300	T=1100	T=900	T=700	T=500	T=300
0	0	0	0	0	0	0
1000	3.09E-02	9.72E-02	0.24	0.46	0.71	0.84
2000	5.14E-02	6.62E-02	8.08E-02	9.35E-02	0.1	0.11
3000	2.35E-02	2.61E-02	2.83E-02	3.00E-02	3.12E-02	3.17E-02
4000	1.14E-02	1.21E-02	1.26E-02	1.30E-02	1.33E-02	1.34E-02
5000	6.23E-03	6.45E-03	6.63E-03	6.76E-03	6.85E-03	6.88E-03
6000	3.73E-03	3.82E-03	3.89E-03	3.94E-03	3.97E-03	3.99E-03
7000	2.40E-03	2.44E-03	2.47E-03	2.49E-03	2.51E-03	2.51E-03
8000	1.63E-03	1.65E-03	1.66E-03	1.68E-03	1.68E-03	1.69E-03
9000	1.15E-03	1.16E-03	1.17E-03	1.18E-03	1.18E-03	1.89E-03
10000	8.46E-04	8.53E-04	8.58E-04	8.61E-04	8.64E-04	8.65E-04

table 4 concentration(mg/l) distance(m)

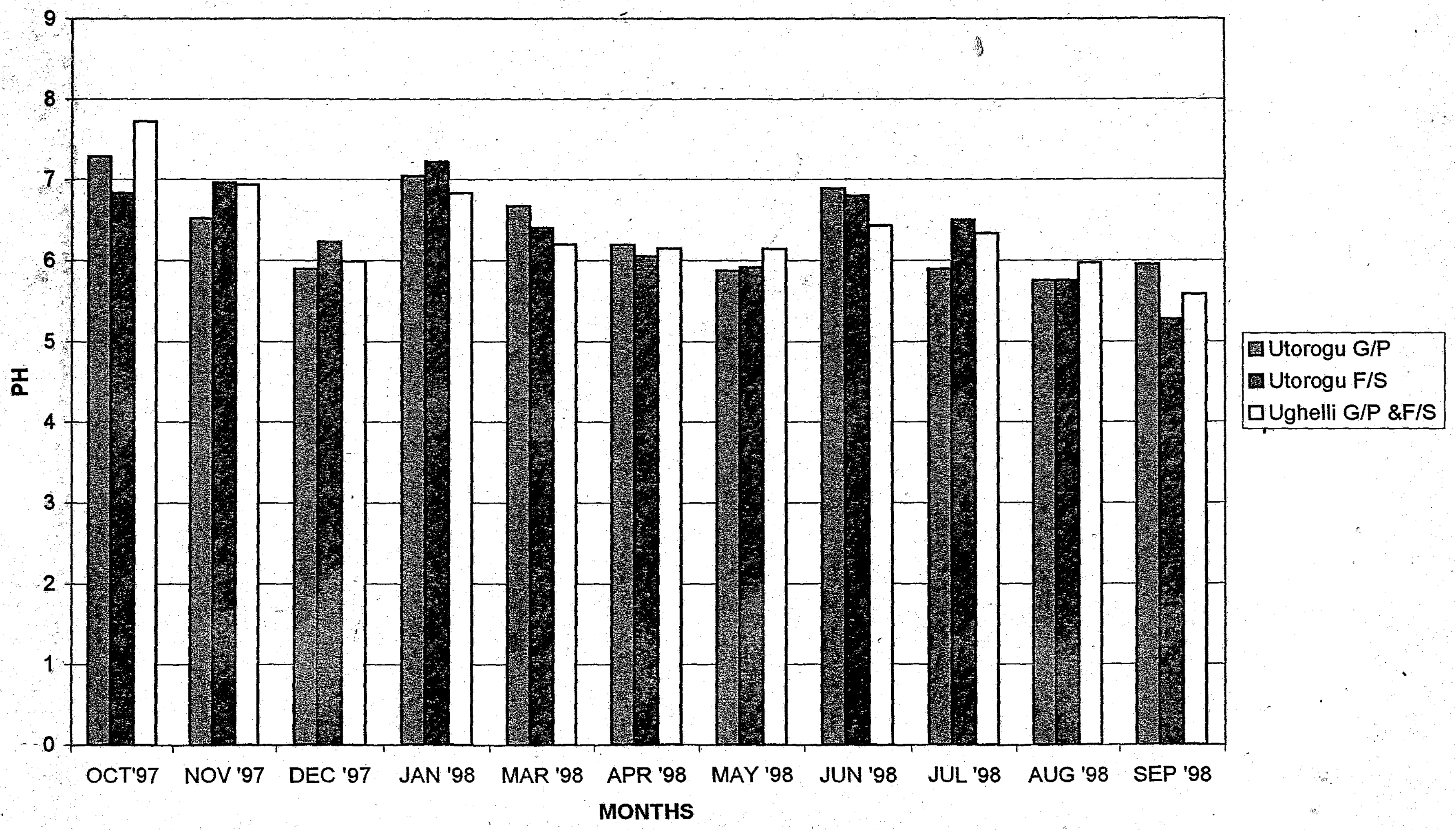
dis(m)	conc(mg/l)
0	0
100	0
200	0
300	4.43E-19
400	3.28E-10
500	2.04E-06
600	1.63E-04
700	1.82E-03
800	7.56E-03
900	1.80E-02
1000	3.09E-02

Mean ph values of rainwater from the monitored stations between OCT'97 & SEPT'98

Month	UTOROGU gas	UTOROGU fl st.	UGHELLI EAST
Oct,97	7.28	6.38	7.72
Nov,97	6.52	6.96	6.93
Dec,97	5.89	6.23	5.99
Jan,98	7.04	7.22	6.83
Mar,98	6.67	6.4	6.2
Apr,98	6.19	6.05	6.15
May,98	5.87	5.91	6.14
Jun,98	6.89	6.8	6.43
Jul,98	5.89	6.5	6.33
Aug,98	5.75	5.75	5.97
Sep,98	5.95	5.27	5.58

```
c1 = ((80000 * k * q) / (.1 * x * pi * s1 * s2 * u))

cc = c1 * h11 * h12
PRINT TAB(12); x: PRINT TAB(27); cc

NEXT x



a$ = INPUT$(1)


SCREEN 12
WINDOW (-.1, 1)-(g, -.1)
LINE (0, 0)-(g, 0), 5
LINE (0, 0)-(0, 1), 5
FOR x = x TO g STEP z * .01
s1 = a * x ^ w

s2 = b * x ^ f

h1 = (-1 / 2 * (y / s1) ^ 2)

h2 = (-1 / 2 * (h / s2) ^ 2)
h11 = EXP(h1)
h12 = EXP(h2)


c1 = ((80000 * k * q) / (.1 * x * pi * s1 * s2 * u))
cc = c1 * h11 * h12

SET (x, cc), 7
EXT x


a$ = INPUT$(1): CLS

INPUT "do you want to compute!another:y/n"; ans$
IF ans$ = "y" THEN
  GOTO 10
END IF
IF ans$ = "n" THEN
 LOCATE 12, 22: PRINT "END OF SESSION!!"
 LOCATE 13, 25: PRINT "GOODBYE..."
END IF
END
```

MEAN PH VALUE OF RAINWATER FROM THE MONITORED STATIONS BETWEEN OCT'97 TO SEPT'98



Mean ph values of rainwater from the monitored stations between OCT'97 & SEPT'98

Month	UTOROGU gas	UTOROGU fl st.	UGHELLI EAST
Oct,97	7.28	6.38	7.72
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Mar,98	6.67	6.4	6.2
Apr,98	6.19	6.05	6.15
May,98	5.87	5.91	6.14
Jun,98	6.89	6.8	6.43
Jul,98	5.89	6.5	6.33
Aug,98	5.75	5.75	5.97
Sep,98	5.95	5.27	5.58

5.2.1 DISCUSSION OF RESULT.

Base on the data of experimental analysis of rain water at distance of 500m, 1000m, and 5,000m available, it is compared with simulated values of 500m, 1,000m, and 5,000m as shown in fig. 1 Although the peak value for simulation was obtained at the distance of 2,000m this is shown in fig 2.

Fig 1, shows a wide difference between experimental and simulation. The difference is due to some factors. These factors are firstly, accumulation of pollutant in the air over long period of time, while the simulation is an instantaneous result. Also some assumptions made for the simulation may not conform to the experimental. Assumptions such as volume of gas flared per month which was assumed to be 11,296.5m^3/month and constant wind speed of 2.7m/s which was assumed did not conform as in real state the wind speed of the environment can not be constant throughout the month. The unstable weather condition that was also assumed for the simulation cannot be the condition of the weather throughout the month. Lastly, in the simulation other pollutants, which could migrate from other sources, were not put into consideration.

In an attempt to conceptualise the model the volume of gas flared was varied to study its effective change in concentration of pollutant. This is shown in fig 2. It is observed from the fig that as the volume of gas flared decrease from 11,296.5m^3/month to 1,000m^3/month, the concentration of pollutant also decreases. This shows the concentration is directly proportional to the volume flared. Also from the fig it is noticed that the peak of the pollutant concentration for various, volume of gas flared at constant temperature of 1300k was obtained at distance of 2,000m from the point of flare. That is distance 2,000m is the danger zone.

The temperature of flaring was also varied from 1,300k to 300k in the attempt to conceptualise the model. This is shown in fig 3. It is observed from the graph that as the temperature decreases from 1,300k to 300k the concentration of the pollutant increases. This means as the temperature decreases the volume of incombust gases increases in the air, therefore led to high concentration of the pollutant. Also from the graph as the temperature decreases the peak value of concentration was observed at 1,000m from the point of flare.

The effect of pollution was also observed at distance of less than 1,000m. This is represented by fig 4. It is observed from the graph that at distance of less than 600m the concentration is almost zero, while the drastically increase in concentration starts at 700m from the point of flare. Therefore distance of less than 600m are free from the effect of the pollution..

There is need to also compare the quality of the rainwater especially the PH with the set limit of the World Health Organisation and Federal Environmental Protection Agency recommended limits of drinking water. Fig. 5 shows the plot of the mean PH value of rainwater from the monitored station during the one year monitoring period.

The World Health Organisation recommend PH limits of drinking water are 6.5 to 8.5 Rain water is source of drinking water to some communities around the monitored area. From the graph is observed that 3 out of 11 rain water monthly mean PH value at Ughelli East gas plant and flow station area were below the lower World Health Organisation limit for the drinking water; at Utorogu flow station it was 7 out of 11; at Utorogu gas plant it was 6 out 11 where below the World Health Organisation PH limit of drinking water.

5.3 CONCLUSION:

It was observed that the modelling was in conformity with the experimental analysis. It can be concluded that the pollution of rain water by the monitored stations were maximum at distance of between 1,500m to 2,500m from the point of flare, while distance less than 1,000m are almost free from pollution, this is a function of wind speed.

The quality of the pollution with respect to physico chemical parameters of the rainwater such as PH is unacceptable to World Health Organisation and Federal Environment Protection Agency Standards.

5.4 RECOMMENDATION.

1 This project suffers some set back due to lack of information and improper record keeping of the company in the area.

2 This kind of research especially as it relates to our environment need a very through assessment, since an improved monitoring programme may help to reduce the pollution problem in Delta state.

3 Government should therefore impose serious sanction on any company that hide information for research purposes.

4 I wish to recommend a more intensive research work based on the data submission to FEPA on monthly basis. Strict measures should be taken against monitored station that fails to submit their physio-chemical parameter of their rainwater analysed as stipulated by the law.

5 The concerned stations within the Delta State should also be contacted for their flaring of gas to the environment, which is rendering the environment

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APPENDIX

```
S
LOR 14, 5

CATE 5, 18: PRINT STRING$(4, 220)
CATE 7, 18: PRINT STRING$(4, 220)
CATE 9, 18: PRINT STRING$(4, 220)
ATE 6, 18: PRINT CHR$(219)
ATE 8, 21: PRINT CHR$(219)

 x = 6 TO 9: LOCATE x, 25: PRINT CHR$(219): NEXT x
ATE 5, 25: : PRINT CHR$(219)

 x = 5 TO 9: LOCATE x, 28: PRINT CHR$(219): NEXT x
 x = 5 TO 9: LOCATE x, 32: PRINT CHR$(219): NEXT x
 x = 5 TO 8: LOCATE x, 30: PRINT CHR$(219): NEXT x
ATE 5, 29: PRINT STRING$(3, 220)

 x = 6 TO 9: LOCATE x, 34: PRINT CHR$(219): NEXT x
 x = 6 TO 9: LOCATE x, 37: PRINT CHR$(219): NEXT x
ATE 9, 34: PRINT STRING$(4, 220)
ATE 5, 34: PRINT CHR$(220): LOCATE 5, 37: PRINT CHR$(220)

 x = 6 TO 9: LOCATE x, 40: PRINT CHR$(219): NEXT x
ATE 5, 40: : PRINT CHR$(219)
ATE 9, 41: PRINT CHR$(220): LOCATE 9, 42: PRINT CHR$(220)

ATE 5, 45: PRINT STRING$(4, 220)
ATE 7, 45: PRINT STRING$(4, 220)
 x = 6 TO 9: LOCATE x, 45: PRINT CHR$(219): NEXT x
 x = 6 TO 9: LOCATE x, 48: PRINT CHR$(219): NEXT x

ATE 5, 51: PRINT STRING$(5, 220)
 x = 6 TO 9: LOCATE x, 53: PRINT CHR$(219): NEXT x

 x = 6 TO 9: LOCATE x, 58: PRINT CHR$(219): NEXT x
ATE 5, 58: : PRINT CHR$(219)

ATE 5, 61: PRINT STRING$(4, 220)
 x = 5 TO 9: LOCATE x, 61: PRINT CHR$(219): NEXT x
 x = 5 TO 9: LOCATE x, 64: PRINT CHR$(219): NEXT x
ATE 9, 61: PRINT STRING$(3, 220)

 x = 5 TO 9: LOCATE x, 68: PRINT CHR$(219): NEXT x
 x = 5 TO 9: LOCATE x, 72: PRINT CHR$(219): NEXT x
ATE 6, 70: PRINT CHR$(220)
ATE 7, 71: PRINT CHR$(220)
CATE 5, 69: PRINT CHR$(220)
ATE 6, 68: PRINT CHR$(220)
ATE 6, 72: PRINT CHR$(220)
ATE 10, 18: PRINT STRING$(80, 205)
ATE 14, 18: PRINT "MATHEMATICAL MODELLING AND COMPUTER SIMULATION OF"
ATE 16, 18: PRINT "RAINWATER POLLUTION FROM GAS FLARING IN NIGER DELTA"
ATE 18, 18: PRINT "BY MAHMUD ISMA'IL"
ATE 20, 18: PRINT "B.ENG/SEET/93/4109"
CATE 23, 40: PRINT "PRESS ANY KEY TO CONTINUE"
= INPUT$(1)

ATE 2, 10: PRINT "THE AIMS AND OBJECTIVES"
ATE 3, 10: PRINT STRING$(22, 196)
ATE 4, 10: PRINT "Operation of gas plants and flow stations in the Niger "
ATE 5, 10: PRINT "Delta area involves flaring of excess gases.Combustion of
ATE 6, 10: PRINT "fossil fuel contribute to atmospheric oxides of sulphur,"
ATE 7, 10: PRINT "nitrogen,and carbon.It also released into atmospheric "
ATE 8, 10: PRINT "hydrocarbon compound and some trace metal i.e lead,mercur
```

```
LOCATE 9, 10: PRINT "e.t.c,which when dissolve in water is harmful to vegetati
LOCATE 10, 10: PRINT "man and aquatic life."
LOCATE 12, 10: PRINT "This project is therefore aimed at developing "
LOCATE 13, 10: PRINT "mathematical modelling as a method of predicting the"
LOCATE 14, 10: PRINT "quantity of gas released into the air during the operati
OCATE 15, 10: PRINT "of oil companies in the Niger-Delta area."
$ = INPUT$(1)
CLS


  'concentration due to gas flaring
0 SCREEN 0, 0: CLS
  INPUT "enter stack discharge velocity(m/s)"; vs
  INPUT "enter stack diameter(m)"; d
  INPUT "enter wind speed(m/s)"; u
  INPUT "enter atmospheric pressure(Mbar)"; p
  INPUT "enter stack discharge temperature(k)"; ts
  INPUT "enter ambient temperature(k)"; ta
  INPUT "enter weather condition"; c
  INPUT "enter name of gas under investigation"; n$
  INPUT "enter height of stack"; hs
  INPUT "enter the flow rate(m^3/month)"; q
  INPUT "enter the distance (y-axis m)"; y
  INPUT "enter the value of k"; k
  INPUT "enter the distance(m)"; g
  INPUT "enter step length"; z

x = .1: w = .903: pi = 3.14159

s = (vs * d) / u * (1.5 + (2.68 ^ -3 * p * d * (ts - ta) / ta))
d1 = s * c
h = hs + d1: CLS

IF g <= 250 THEN
   a = .4: b = .125: f = 1.03
END IF

IF g > 250 OR g <= 500 THEN
   a = .4: b = .00883: f = 1.51
END IF

IF g > 500 OR g <= 1000 THEN
   a = .295: b = .119: f = .986
END IF
IF g > 1000 OR g <= 10000 THEN

   a = .295: b = .0579: f = 1.09
END IF

IF c = 1 THEN : LOCATE 4, 12: PRINT "the condition is neutral"
IF c = 1.15 THEN : LOCATE 4, 12: PRINT "the condition is unstable"
IF c = .85 THEN : LOCATE 4, 12: PRINT "the conndition is stable"
LOCATE 6, 12: PRINT "distance(M)": LOCATE 6, 27: PRINT "concentration(mg/l)

FOR x = x TO g STEP z
s1 = a * x ^ w

s2 = b * x ^ f

h1 = (-1 / 2 * (y / s1) ^ 2)

h2 = (-1 / 2 * (h / s2) ^ 2)
h11 = EXP(h1)
h12 = EXP(h2)
```

```
c1 = ((80000 * k * q) / (.1 * x * pi * s1 * s2 * u))

cc = c1 * h11 * h12
PRINT TAB(12); x: PRINT TAB(27); cc

NEXT x



a$ = INPUT$(1)


SCREEN 12
WINDOW (-.1, 1)-(g, -.1)
LINE (0, 0)-(g, 0), 5
LINE (0, 0)-(0, 1), 5
FOR x = x TO g STEP z * .01
s1 = a * x ^ w

s2 = b * x ^ f

h1 = (-1 / 2 * (y / s1) ^ 2)

h2 = (-1 / 2 * (h / s2) ^ 2)
h11 = EXP(h1)
h12 = EXP(h2)


c1 = ((80000 * k * q) / (.1 * x * pi * s1 * s2 * u))
cc = c1 * h11 * h12
SET (x, cc), 7
EXT x


a$ = INPUT$(1): CLS

INPUT "do you want to compute!another:y/n"; ans$
IF ans$ = "y" THEN
  GOTO 10
END IF
IF ans$ = "n" THEN
 LOCATE 12, 22: PRINT "END OF SESSION!!"
 LOCATE 13, 25: PRINT "GOODBYE..."
END IF
END
```

Fig. 4: CONCENTRATION (mg/l) Vs DISTANCE(m)

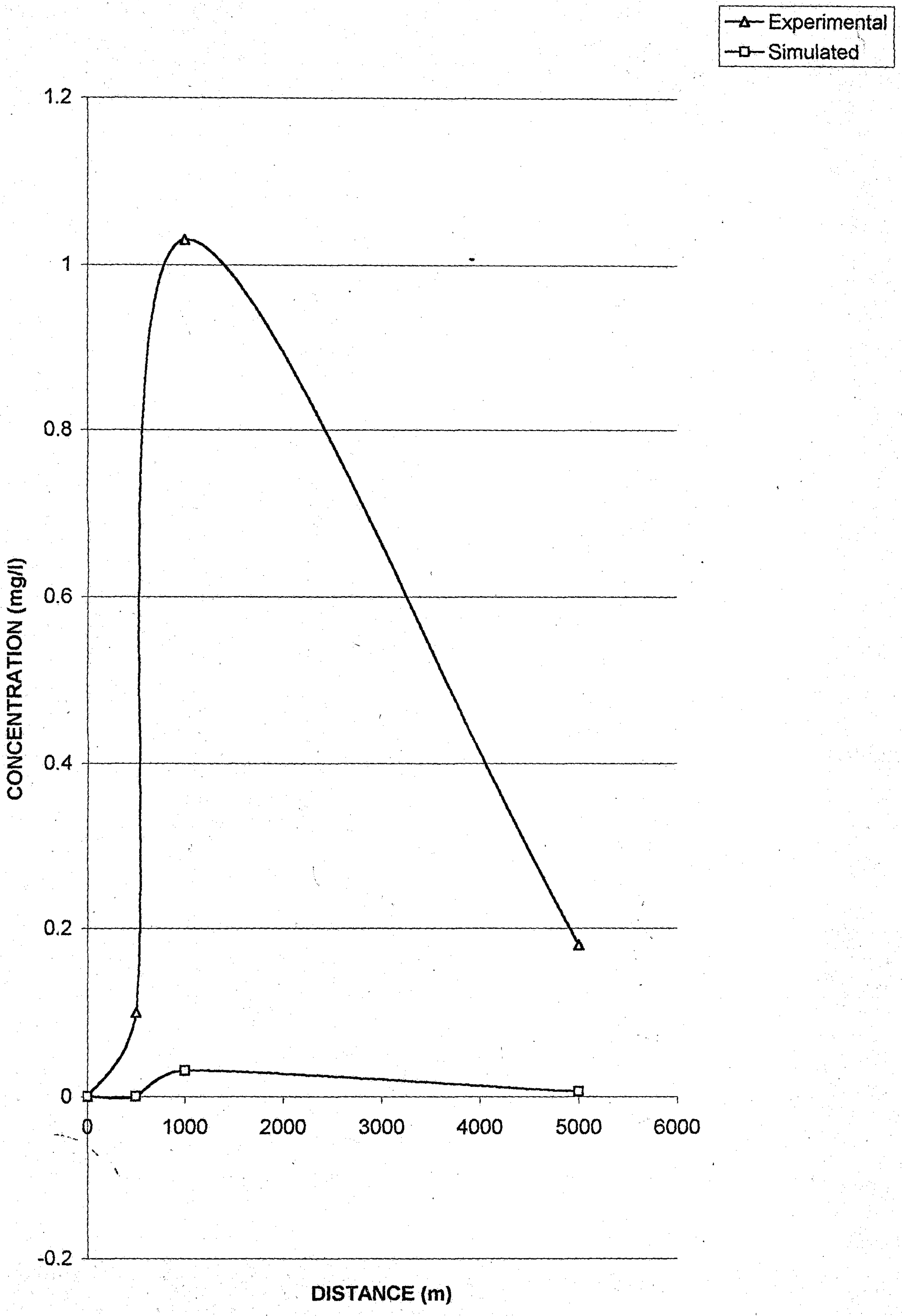
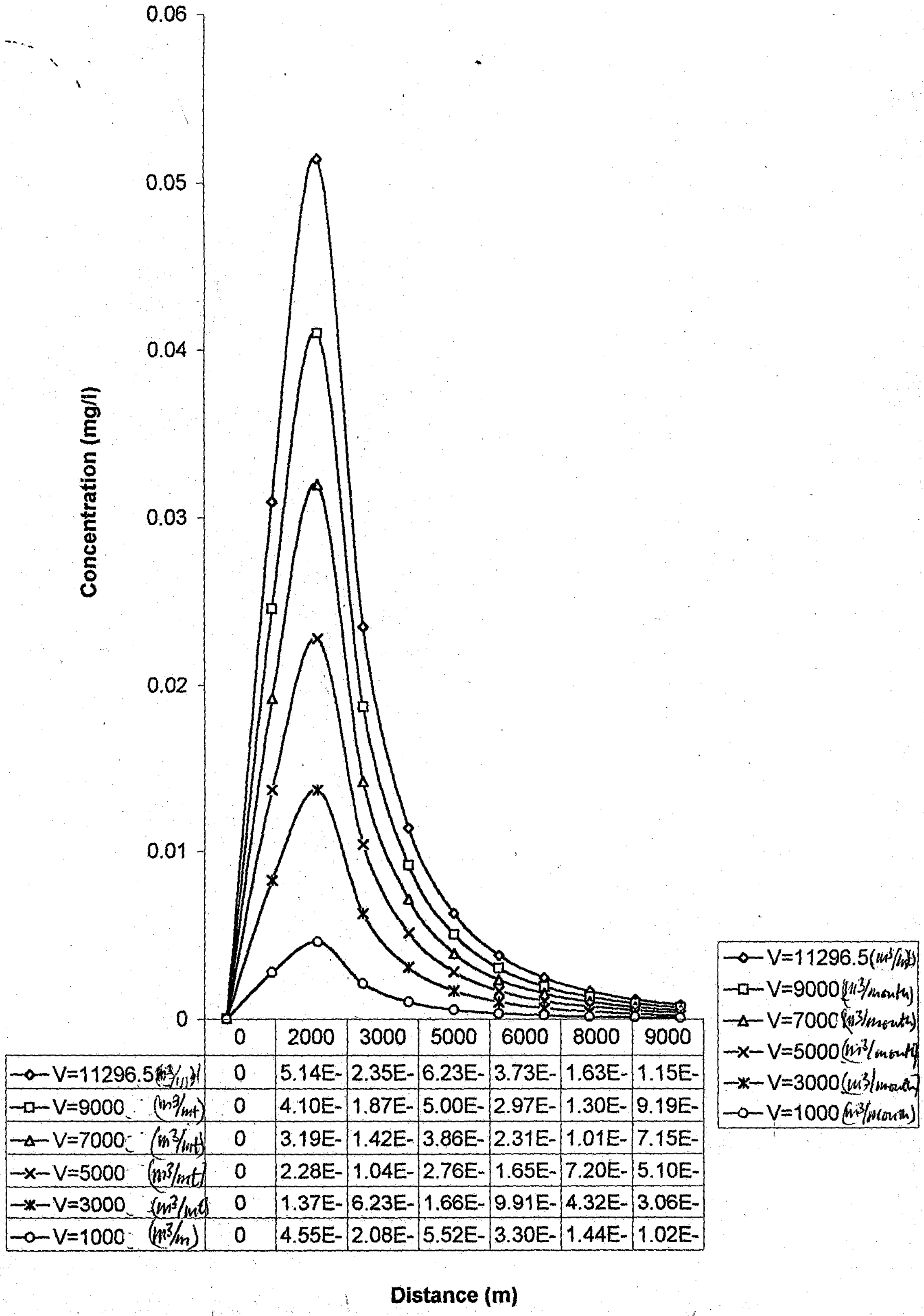
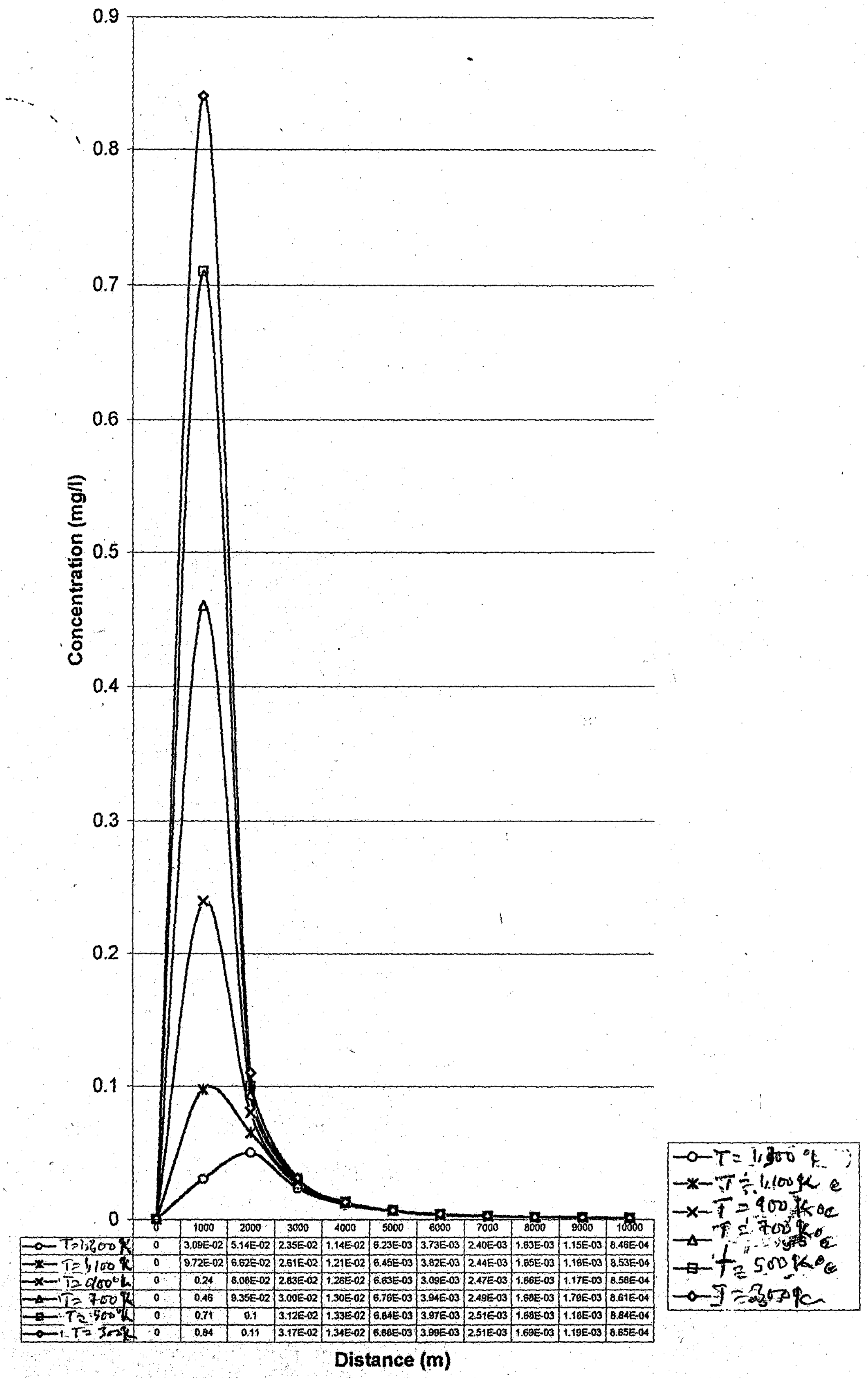


Fig. 2: Graph of Concentration (mg/l) Vs Distance (m) for variuos volumes AT TEMPERATURE OF 1,300K



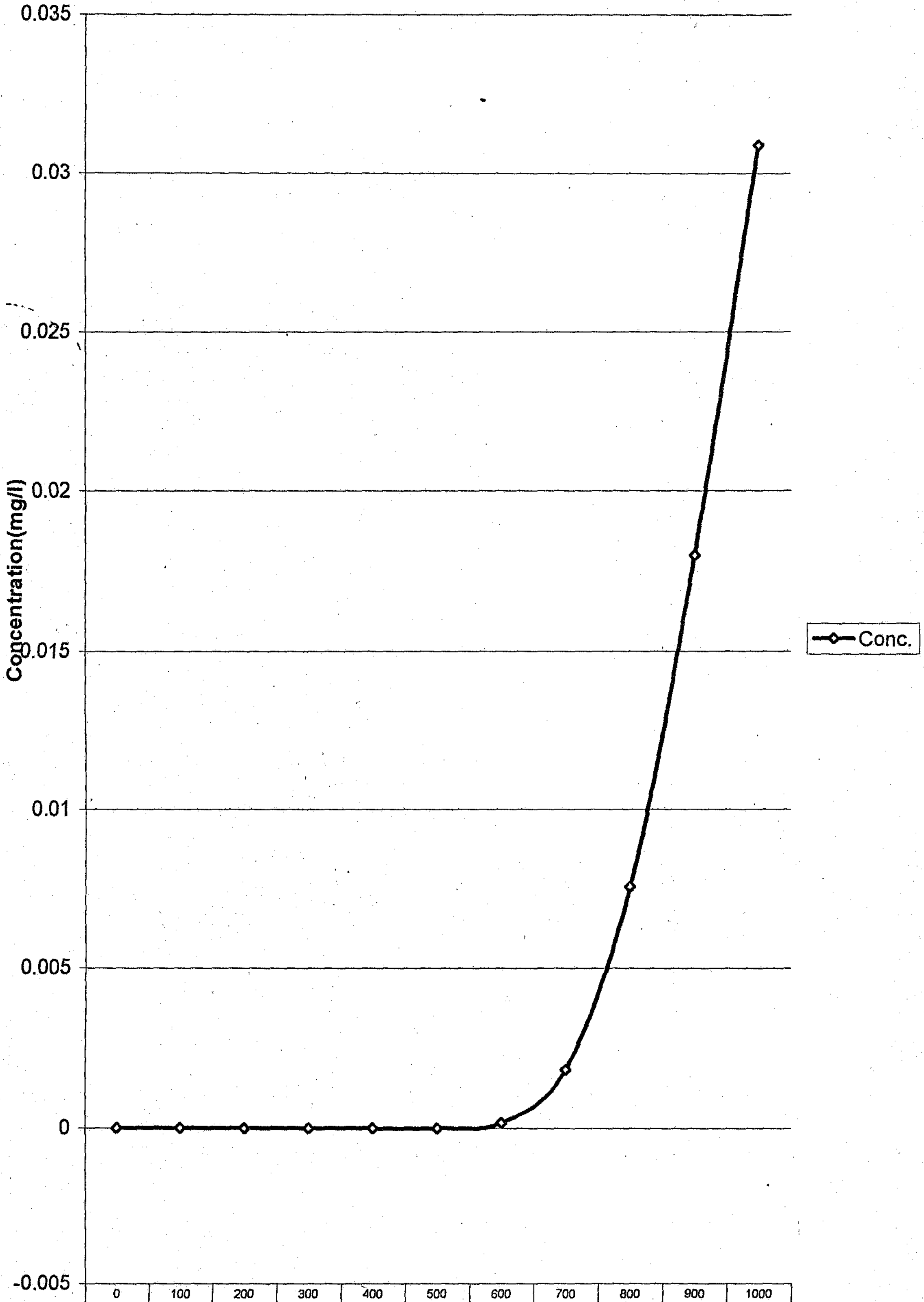
	0	2000	3000	5000	6000	8000	9000
V=11296.5 (m^3/mt)	0	5.14E-	2.35E-	6.23E-	3.73E-	1.63E-	1.15E-
V=9000 (m^3/mt)	0	4.10E-	1.87E-	5.00E-	2.97E-	1.30E-	9.19E-
V=7000 (m^3/mt)	0	3.19E-	1.42E-	3.86E-	2.31E-	1.01E-	7.15E-
V=5000 (m^3/mt)	0	2.28E-	1.04E-	2.76E-	1.65E-	7.20E-	5.10E-
V=3000 (m^3/mt)	0	1.37E-	6.23E-	1.66E-	9.91E-	4.32E-	3.06E-
V=1000 (m^3/m)	0	4.55E-	2.08E-	5.52E-	3.30E-	1.44E-	1.02E-

Fig. 3: Graph of Concentration (mg/l) Vs Distance (m) for various Temperature AT VOLUME OF ~~11~~: 11,296.5(m3/month)



	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
T=1,800 K	0	3.09E-02	5.14E-02	2.35E-02	1.14E-02	6.23E-03	3.73E-03	2.40E-03	1.63E-03	1.15E-03	8.46E-04
T=1,100 K	0	9.72E-02	6.62E-02	2.61E-02	1.21E-02	6.45E-03	3.82E-03	2.44E-03	1.65E-03	1.16E-03	8.53E-04
T=900°K	0	0.24	8.08E-02	2.83E-02	1.26E-02	6.63E-03	3.09E-03	2.47E-03	1.66E-03	1.17E-03	8.58E-04
T=700 K	0	0.46	9.35E-02	3.00E-02	1.30E-02	6.76E-03	3.94E-03	2.49E-03	1.68E-03	1.79E-03	8.61E-04
T=500°K	0	0.71	0.1	3.12E-02	1.33E-02	6.84E-03	3.97E-03	2.51E-03	1.68E-03	1.18E-03	8.64E-04
T=300K	0	0.84	0.11	3.17E-02	1.34E-02	6.88E-03	3.99E-03	2.51E-03	1.69E-03	1.19E-03	8.65E-04

Fig. 1:Graph of Concentration(mg/l) Vs Distance(m).



	0	100	200	300	400	500	600	700	800	900	1000
Conc.	0	0	0	4.43E-19	3.28E-10	2.04E-06	1.63E-04	1.82E-03	7.56E-03	1.80E-02	3.09E-02

MEAN PH VALUE OF RAINWATER FROM THE MONITORED STATIONS BETWEEN OCT'97 TO SEPT'98