A STUDY ON WATER POLLUTION IN CROW ISLAND MID CANAL

This is to certify that this dissertation was submitted for the B.Sc degree programme of the Open University of Sri Lanka.

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A STUDY ON WATER POLLUTION IN CROW ISLAND MID CANAL

by

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CONTENTS

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ABSTRACT

Water pollution of Crow Island mid canal draining through a densly populated and moderately industrialised area of Mttakkuliya was studied. Water samples were collected from four sampling stations at four field visits made in April and May of 1990 and analysed for fourteen physical and chemical parameters.

Extremely low levels of Dissolved Oxygen and high levels of Biochemical Oxygen Demand and Permanganate Value were found indicating the presence of heavy loads of oxidizable organic matter in the canal water. Major cations, Nitrogen species and Chloride concentrations were also much greater than those found in many other estuaries of Sri Lanka. Eventhough, pH of the canal water was almost neutral, chemical parameters examined in this study suggested that the canal is highly polluted as a result of anthropogenic activities.

CHAPTER 1

INTRODUCTION

The Crow Island mid canal draining through Mattakkuliya, Colombo 15 was selected for this study. The canal is approximately 4m in width and 2km in length and is stone paved only in some regions. The mid canal which runs through an extremely dense network of industrial and residential areas appears to be highly polluted. On its route, it collects massive loads of domestic sewage as well as industrial effluents discharged from various establishments in the vicinity. Over the last two decades Crow Island area has been developed into an industrial township with the setting up of several big factory complexes and many small scale industries. The major industries established in the area are leather factory, textile mill, tea blending factory etc. These industries use various chemicals for their production processes and most of the factories release effluents to the mid canal which flows to the Kelani river.

The water of the canal appears to be stagnant or flowing very slowly due to accumulation of domestic as well as industrial wastes. As a result, hydrogen sulphide (H_2S) emanates from the canal as detectable by its characteristic odour. The colour of the water being black, is also indicative of aquatic pollution of the canal.

The proposed study will be a case study for industrial pollution of an urban canal draining through a highly populated region of the city. The objective of this study is to ascertain the levels and distribution of the pollutants in the canal water.

The chemical parameters examined were Nitrite, Nitrate, Ammonia, Phosphate, Chloride and Ferrous ion concentration, permanganate value, (i.e. Chemical Oxygen Demand), Biochemical Oxygen Demand, Dissolved Oxygen and pH value.

CHAPTER 2

MATERIALS AND METHODS

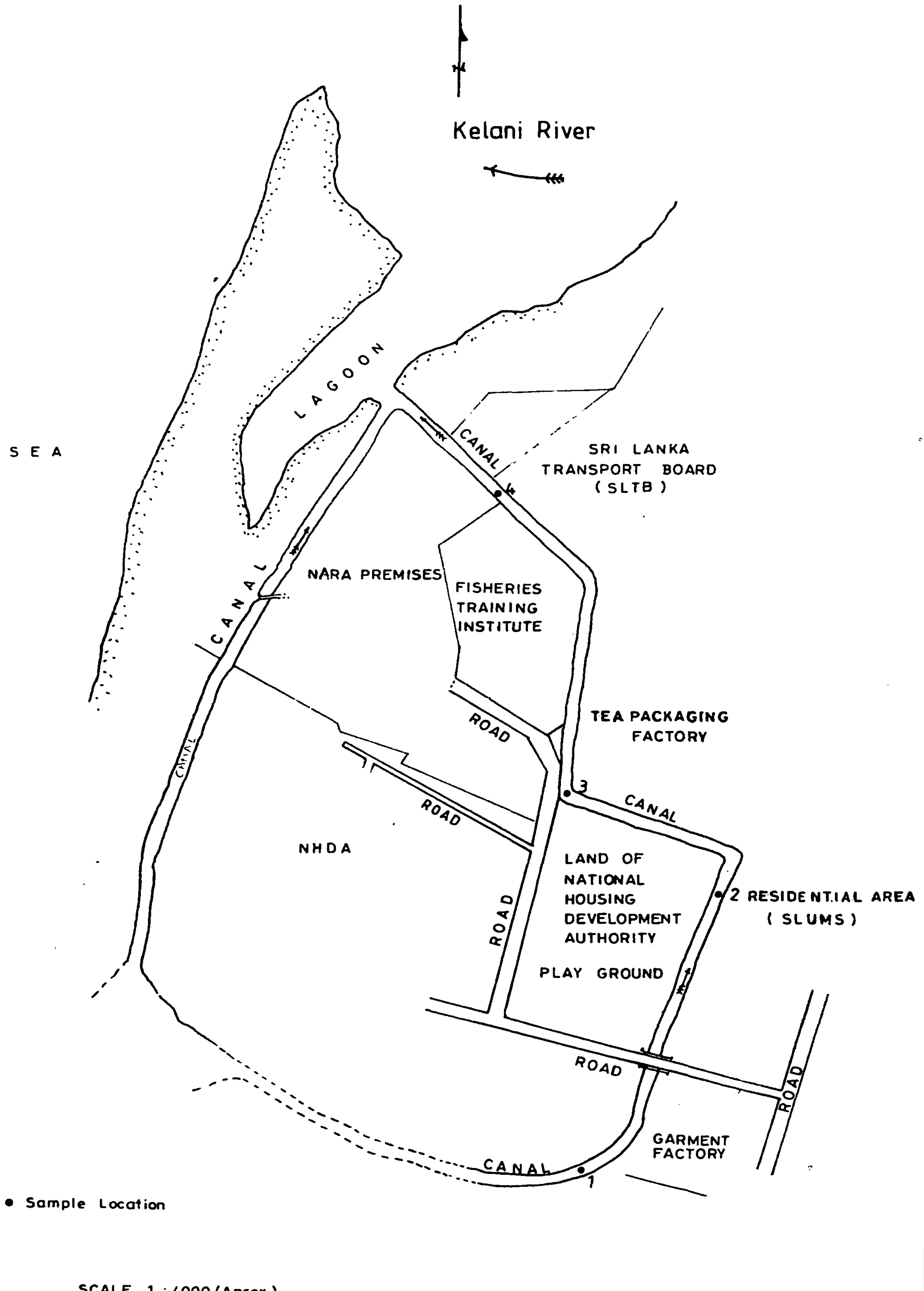
2.1 SAMPLING

The water sampling locations were selected using a large scale map of the Mattakkuliya area. The sampling points were selected so as to represent the places where different types of effluent discharges occur. Fig.1 illustrates the selected sampling stations along the Crow Island mid canal in Mattakkuliya, Colombo 15.

The sampling bottles were cleaned well with Hydrochloric acid (HCl), rinsed with distilled water and dried before use (APHA, 1985). Water samples were collected in these bottles and were analysed as soon as possible. Four sampling visits were made to the Crow Island mid canal in April and May 1990, under dry as well as rainy weather conditions. Samples were collected from each of the four selected sampling stations.

2.2 DETERMINATION OF CHEMICAL PARAMETERS IN WATER SAMPLES

The chemical analysis of water was carried



Kelani River
SEA
LAGOON
CANAL
CANAL
SRI LANKA
TRANSPORT BOARD
(SLTB)
NARA PREMISES
FISHERIES
TRAINING
INSTITUTE
ROAD
TEA PACKAGING
FACTORY
CANAL
3
CANAL
ROAD
NHDA
LAND OF
NATIONAL
HOUSING
DEVELOPMENT
AUTHORITY
2 RESIDENTIAL AREA
(SLUMS)
ROAD
PLAY GROUND
ROAD
ROAD
GARMENT
FACTORY
CANAL
1
• Sample Location
SCALE 1 : 4000 (Aprox.)

Fig. 1

out in the laboratory of the Environmental Study Unit of the National Aquatic Resources Agency (NARA) at Crow Island, Mattakkuliya, Colombo 15. All chemical analyses were carried out according to the standard methods recommended for the examination of water and waste water (APHA, 1985).

The pH and the temperature of water samples were measured in situ. Nitrate, Nitrite, Ammonia, Phosphate and Ferrous ion concentrations were determined by spectrophotometric methods whereas Calcium, Magnesium, Chloride, Total Hardness, Biochemical Oxygen Demand, Permanganate value and Dissolved Oxygen were analysed by titrimetric methods.

The analytical methods are given below in detail.

2.2.1 DETERMINATION OF TOTAL HARDNESS

Total hardness of water is defined as the sum of Calcium and Magnesium ion concentrations expressed in miligrams per litre (mg/l or ppm).

Thus, Total Hardness $= (Ca^{2+} + Mg^{2+})$ mg/l

Total Hardness was determined by adding 0.5ml of NH_4OH to 50 ml aliquot of water sample and by titrating the sample with 0.01 M EDTA solution using Eriochrome Black T as the indicator.

Calculation

$$\text{Total Hardness as } CaCO_3 = \frac{A \times B \times 1000}{C} \text{ mg/l}$$

Where,

A = Volume of EDTA used (in ml)

B = mg $CaCO_3$ equivalent to 1ml of EDTA titrant

C = Volume of the sample (in ml)

2.2.2 DETERMINATION OF CALCIUM HARDNESS

A 50 ml aliquot of the sample was spiked with 2.5 ml of 1 M NaOH solution and titrated with 0.01 M EDTA solution using murexide as the indicator.

Calculation

$$\text{Calcium Hardness as } Ca^{2+} = \frac{A \times B \times 1000}{C} \text{ mg/l}$$

where,

A = Volume of EDTA used (in ml)

B = mg Ca^{2+} equivalent to 1 ml of EDTA

C = Volume of the sample (in ml)

2.2.3 DETERMINATION OF MAGNESIUM HARDNESS

Magnesium hardness was calculated by deducting calcium hardness from the total hardness.

Calculation

$$\text{Magnesium Hardness as } Mg^{2+} = \frac{(A - B)\,D}{C} \text{ mg/l}$$

where,

A = Total Hardness as Ca^{2+}

B = Ca^{2+} Hardness as Ca^{2+}

C = Atomic weight of Calcium

D = Atomic weight of Magnesium

2.2.4 DETERMINATION OF CHLORIDE ION CONCENTRATION

A 10 ml aliquot of sample was titrated with 0.03 M $AgNO_3$ using 2-3 drops of K_2CrO_4 as the indicator

Calculation

$$Cl^- + AgNO_3 \text{ ---------> } AgCl(s) + NO_3^-$$

$$Cl^- \text{ concentration} = \frac{A \times B \times 1000 \times 35.5}{C} \text{ mg/l}$$

where,

A = molar concentration of $AgNO_3$ solution

B = Volume of $AgNO_3$ (in ml)

C = Volume of sample (in ml)

2.2.5 DETERMINATION OF AMMONIA (NH_3)

To a 50 ml portion of the sample, 0.5 ml of 0.6 M $ZnSO_4$ was added and the pH of the solution was adjusted to 10.5 with NaOH solution. Two drops of EDTA was added to the solution and filtered through a filter paper. A 10 ml aliquot of the filtrate was spiked with 0.2 ml of Nessler reagent and mixed thoroughly. The ammonia content of water sample was determined by measuring the absorbance of the resulting solution at 412.5 nm wavelength using a UV/ visible spectrophotometer (Shimudzu Model 160).

2.2.6 DETERMINATION OF PHOSPHATE (PO_4^{3-})

To a 10 ml portion of the sample, 2 ml of ascorbic mixture (which was prepared by mixing 25 ml of H_2SO_4, 2.5 ml of potassium antimonyl tartarate, 7.5 ml of ammonium molybdate and 15 ml of ascorbic acid solutions together) was added and mixed thoroughly. The measurement of PO_4^{3-} content in the sample was carried out spectrophotometrically at 882.0 nm wavelength.

2.2.7 DETERMINATION OF NITRATE (NO_3^-)

To a 5 ml aliquot of the sample, 5 ml of sulphuric acid and 0.25 ml of Brucine Sulphate were added and cooled for 20 minutes in a water bath. The nitrate content of the sample was measured spectrophotometrically (wavelength 543 nm). The blank measurement was made in distilled water and substracted from the sample reading for the calculation of the nitrate content in the sample.

2.2.8 DETERMINATION OF NITRITE (NO_2^-)

A 10 ml portion of the sample was mixed thoroughly with 0.2 ml of sulphanilamide and 0.2 ml of NED [N - (1 - napthyl) ethylene diamine dihydrochloride] solution. The nitrite ion content of the sample was measured by spectrophotometer at 410 nm wavelength.

2.2.9 DETERMINATION OF FERROUS ION (Fe^{2+})

To a 50 ml portion of the sample 1 ml of HNO_3 solution was added and heated for 20 minutes. To this solution 5 ml of thioglycolic acid, 2 ml of ammonium citrate and 5 ml of NH_4OH were added and mixed thoroughly. Ferrous ion content in the sample was determined by means of a spectrophotometer (wavelength 535 nm).

2.2.10 DETERMINATION OF DISSOLVED OXYGEN (DO)

The water samples for the determination of DO were collected by dipping the sample bottles in the canal. The bottles were treated with Winkler reagents A & B ($MnSO_4$ & Alkaline KI) stoppered immediately and taken back to the laboratory. DO in water was measured using Winkler method.

Calculation

$$O_2 \text{ mg/l} = \frac{\text{ml of titrant X normality of titrant X 8 X 100}}{\text{ml of sample titrated}}$$

2.2.11 DETERMINATION OF PERMANGANATE VALUE (PV)

To a 5 ml aliquot of the sample, 5 ml each of H_2SO_4 and 0.025M $KMnO_4$ were added, mixed thoroughly and kept for four hours. A small amount of 0.9 M alkaline KI solution was then added to the solution and iodine liberated was titrated with 0.02 M $Na_2S_2O_3$ solution using starch as the indicator.

Calculation

$$2MnO_4^- + 16H^+ + 10I^- \longrightarrow 2Mn^{2+} + 8H_2O + 5I_2 \quad \text{--- (1)}$$

$$I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-} \quad \text{--- (2)}$$

---

(1) + 5 X (2)

$$2MnO_4^- + 16H^+ + 10S_2O_3^{2-} \longrightarrow 2Mn^{2+} + 8H_2O + 5S_4O_6^{2-}$$

$$MnO \text{ remaining in solution} = \frac{1}{5}(S_2O_3^{2-} \text{ consumed})$$

2.2.12 DETERMINATION OF BIOCHEMICAL OXYGEN DEMAND (BOD)

The DO values of canal water indicated that a dilution of water samples with aerated water is required to determine BOD values.

A 50 ml of sample was poured into a measuring cylinder and diluted up to 500 ml with areated distilled water. Then two 165 ml DO bottle were filled with the mixture and one was fixed by winkler reagents for initial DO determination. The other was incubated at room temperature for 3 days and then the final DO level was determined.

The BOD values were calculated as follows;

Calculation

$$BOD\ (mg/l) = \frac{D_1 - D_2}{P}$$

where,

D_1 = initial DO value

D_2 = Do value after 3 days

$$P = \frac{\text{Volume of waste water}}{\text{Volume of dilute water + waste water}}$$

CHAPTER 3

RESULTS AND DISCUSSION

Sampling dates and the weather conditions are as follows;

Day 1	1990-04-19	Rainy, low tide
Day 2	1990-05-08	Rainy, high tide
Day 3	1990-05-21	Dry, low tide
Day 4	1990-05-23	Dry, low tide

3.1 PHYSICAL PARAMETERS (TEMPERATURE & pH)

When considering the physical parameters, temperature fluctuated between 31 and 33 ^{o}C. Fig. 2 indicates that the changes of the temperature of the canal with respect to sampling station and sampling date are small, usually 1 ^{o}C from the averages. This suggests that the temperature along the canal is relatively constant on any particular day.

The pH of the canal water varied between 6.35 and 7.31 as given in Fig. 3. The canal water, therefore, appears to be more or less neutral during the study period. Thus the physical parameters may not have a considerable impact on the quality of water.

FIG. 2 - VARIATION OF TEMPERATURE IN CANAL WATER

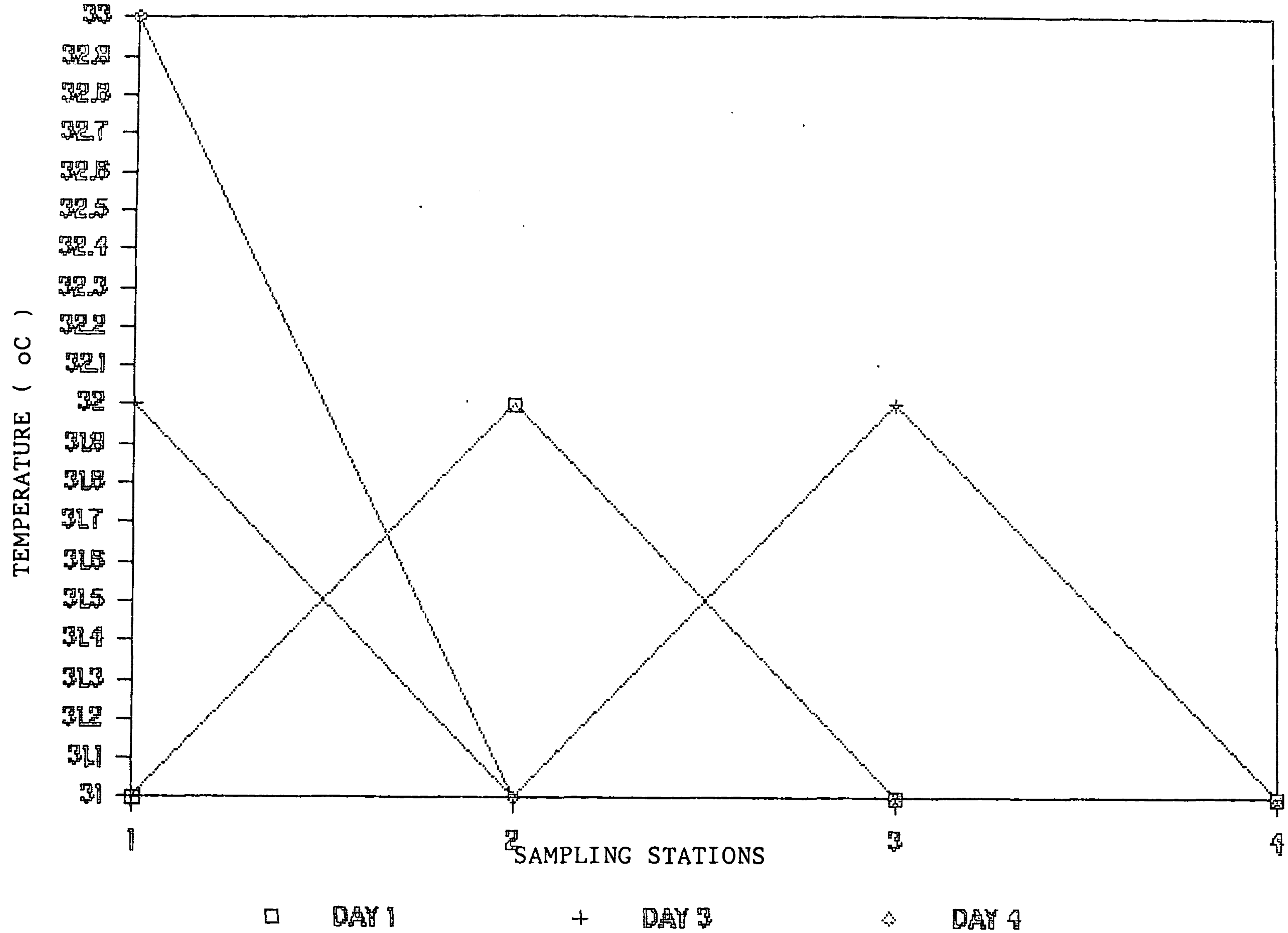
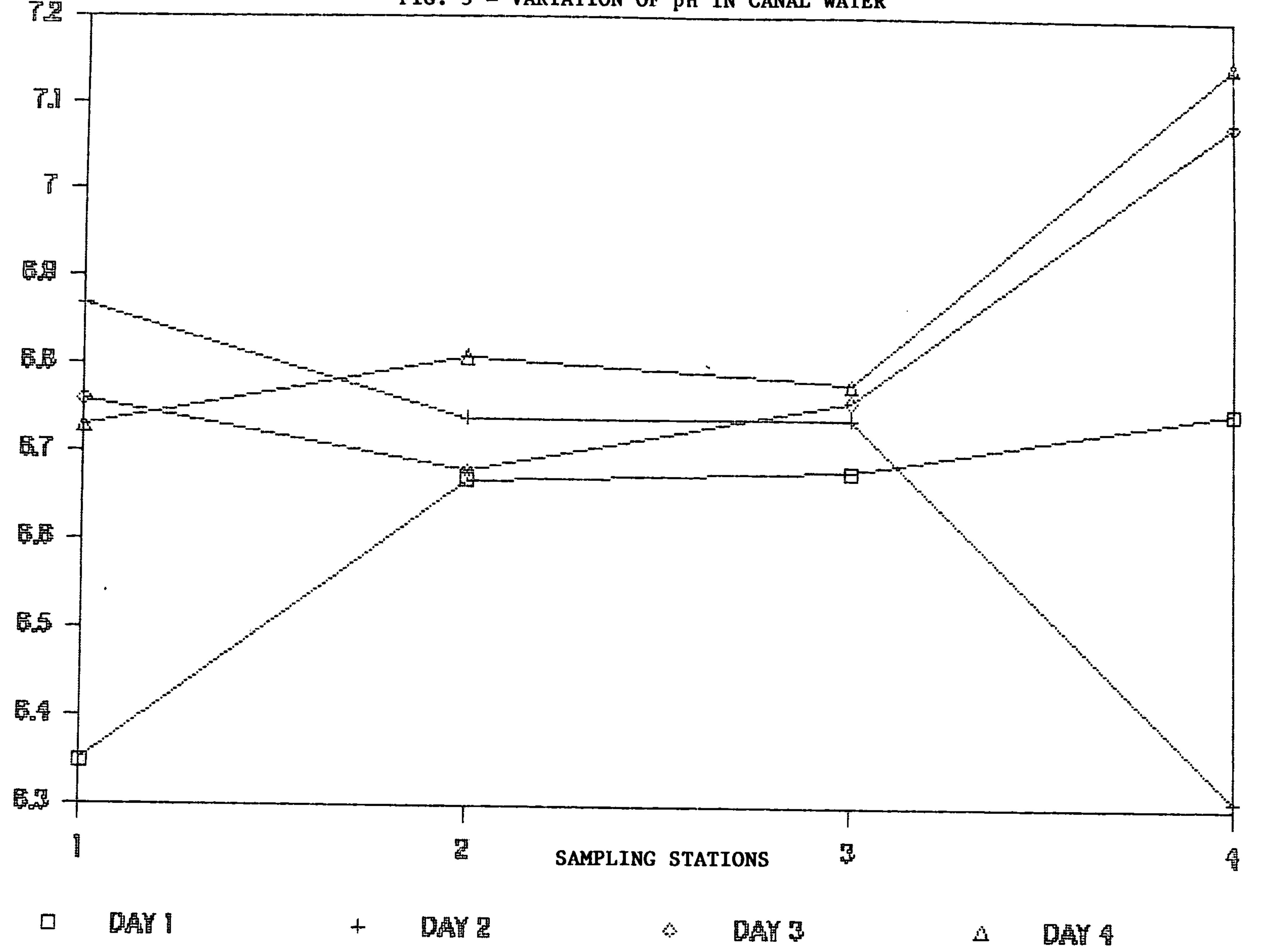


FIG. 3 - VARIATION OF pH IN CANAL WATER



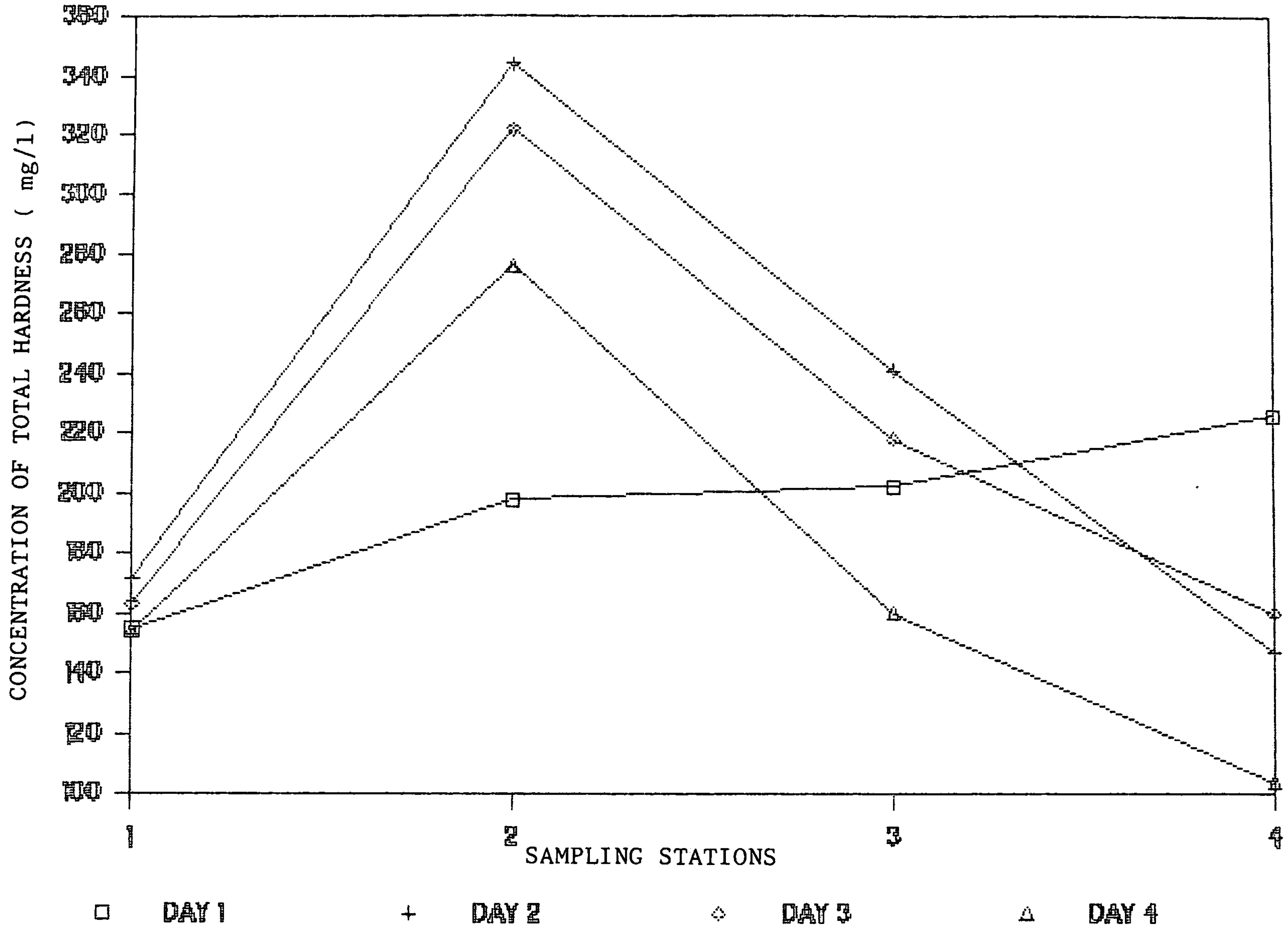
The slight variation of pH in the canal water at different sampling stations on the same day and at the same sampling station on different days may be due to the fluctuations of CO_2 resulting from photosynthesis and respiration of water hyacinth, salvinia etc. grown in the canal. Water becomes acidic towards the latter part of the night and early morning due to the accumulation of CO_2 from respiration and inhibition of photosynthesis. Most unpolluted waters have pH slightly greater than 7, but the polluted water is generally acidic. Eventhough the pH of the mid canal is near neutral, visual observations indicate that it is highly polluted. The pH of sampling station 4 is generally higher than those of other stations due to proximity to the sea (about 300 m).

3.2 WATER HARDNESS

3.2.1 TOTAL HARDNESS

Originally, water hardness was understood to be a measure of the capacity of water to precipitate soap. Soap is precipitated chiefly by calcium and magnesium ions present present in water. Total hardness is defined as the sum of the calcium and magnesium concentrations, both expressed as calcium carbonate, in miligrams per liter. The hardness may

FIG. 4 - VARIATION OF TOTAL HARDNESS IN CANAL WATER



range from zero to hundreds of milligrams per liter, depending on the source and treatment to which the water has been subjected (APHA, 1985).

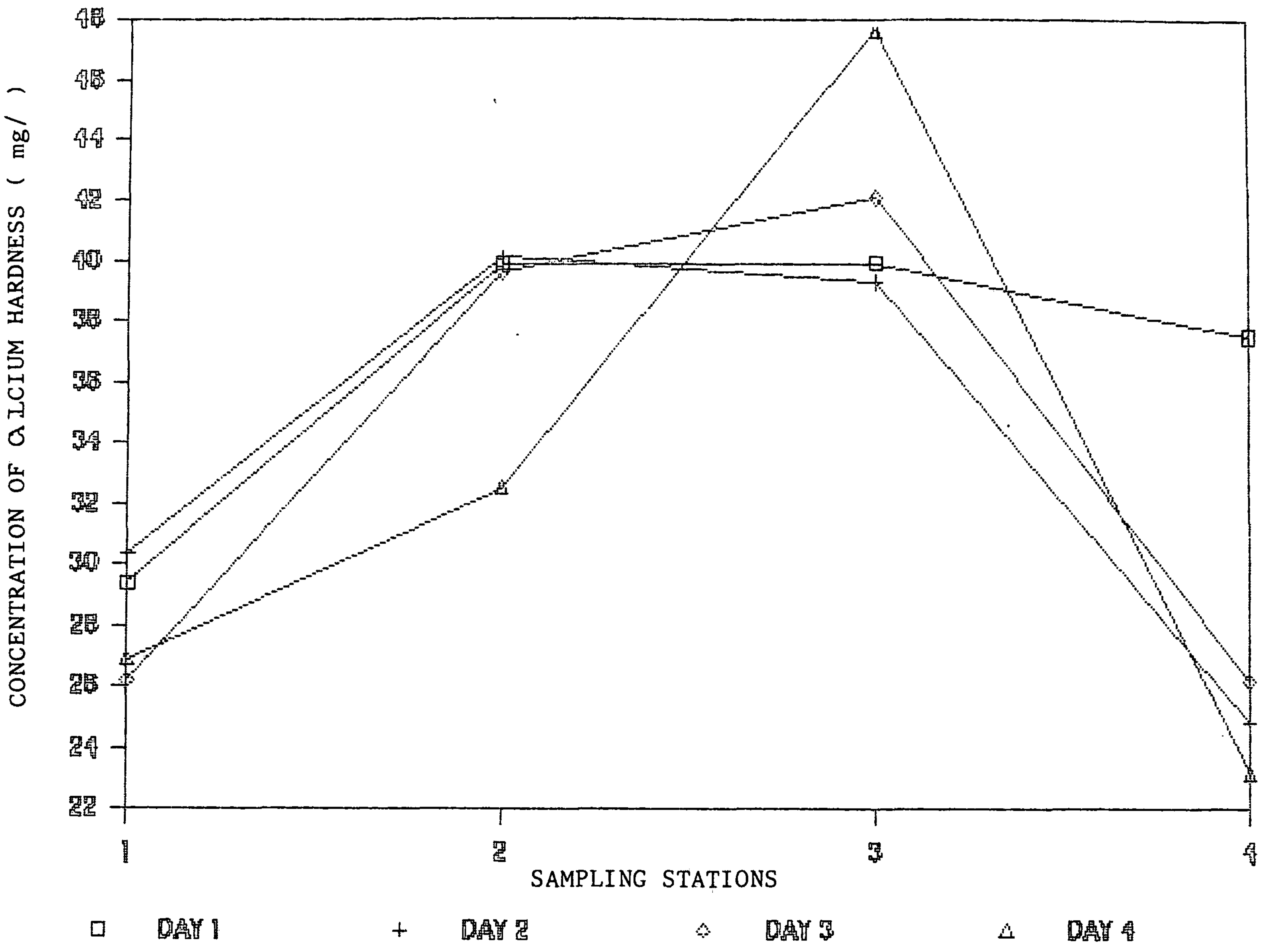
A degree of total hardness is equivalent to a total calcium and magnesium molarity of 10^{-4}. Anything in excess of 20 degrees of hardness is considered really hardwater (APHA, 1985).

The total hardness of the canal water is plotted against sampling point in Fig. 4. On all sampling days (except day 1) sampling station 2 showed a higher value for total hardness than other stations and the greatest fluctuation among the values. This could be due to the discharge of domestic waste of various magnitude from nearby slums. Other sampling stations indicate more or less similar values. The variation of the values of total hardness (TH) seems to follow a regular pattern except for day 1.

3.2.2 CALCIUM HARDNESS

The variation of calcium hardness seems to follow a regular pattern on all sample collection days (Fig. 5). Sampling station 1 and 4 shows less calcium concentrations compared to the other two stations. Eventhough sampling station 4 is closer to

FIG. 5 - VARIATION OF CALCIUM HARDNESS IN CANAL WATER



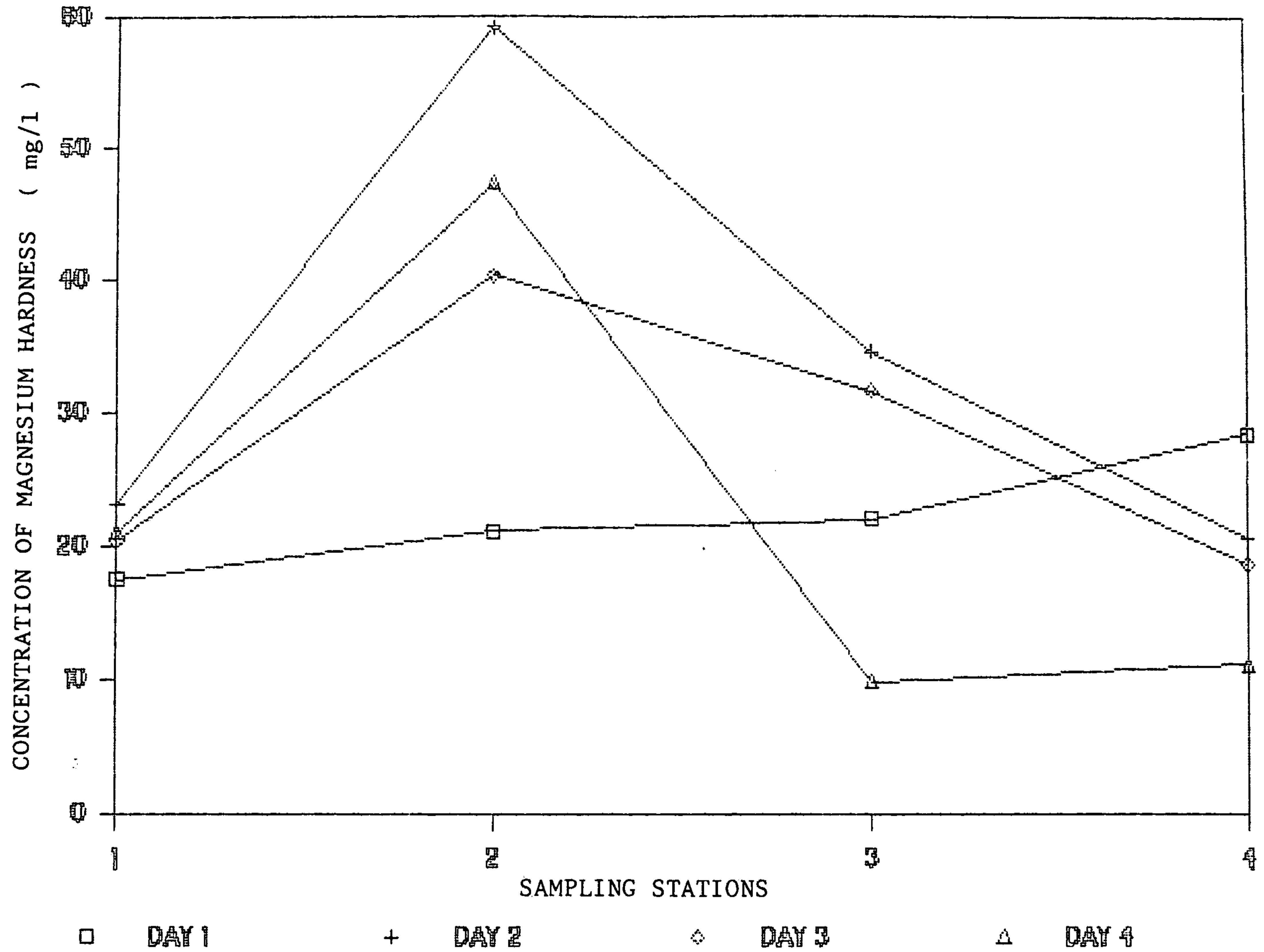
the sea than other stations, the calcium ion concentration at station 4 is much less than those of the latter points. This is in contrast to the expected trend.

3.2.3 MAGNESIUM HARDNESS

Magnesium ranks eighth among the elements in order of abundance and is a common constitutent of natural water. The magnesium concentration may vary from zero to several hundred miligrams per litre depending on the source and treatment of the water (APHA, 1985).

Fig. 6 indicates that on the first sampling day, the level of magnesium remains constant up to the 3rd sampling point with a slight increase at the 4th sampling station. Generally, sampling station 2 shows a much higher magnesium concentration than other sampling points. As shown in Fig. 4 total hardness at sampling point 2 is also high on all sampling dates but the calcium ion content is moderate (Fig. 5). This suggests the presence of a magnesium source (effuluent discharge containing magnesium) near sampling station 2.

FIG. 6 - VARIATION OF MAGNESIUM HARDNESS IN CANAL WATER



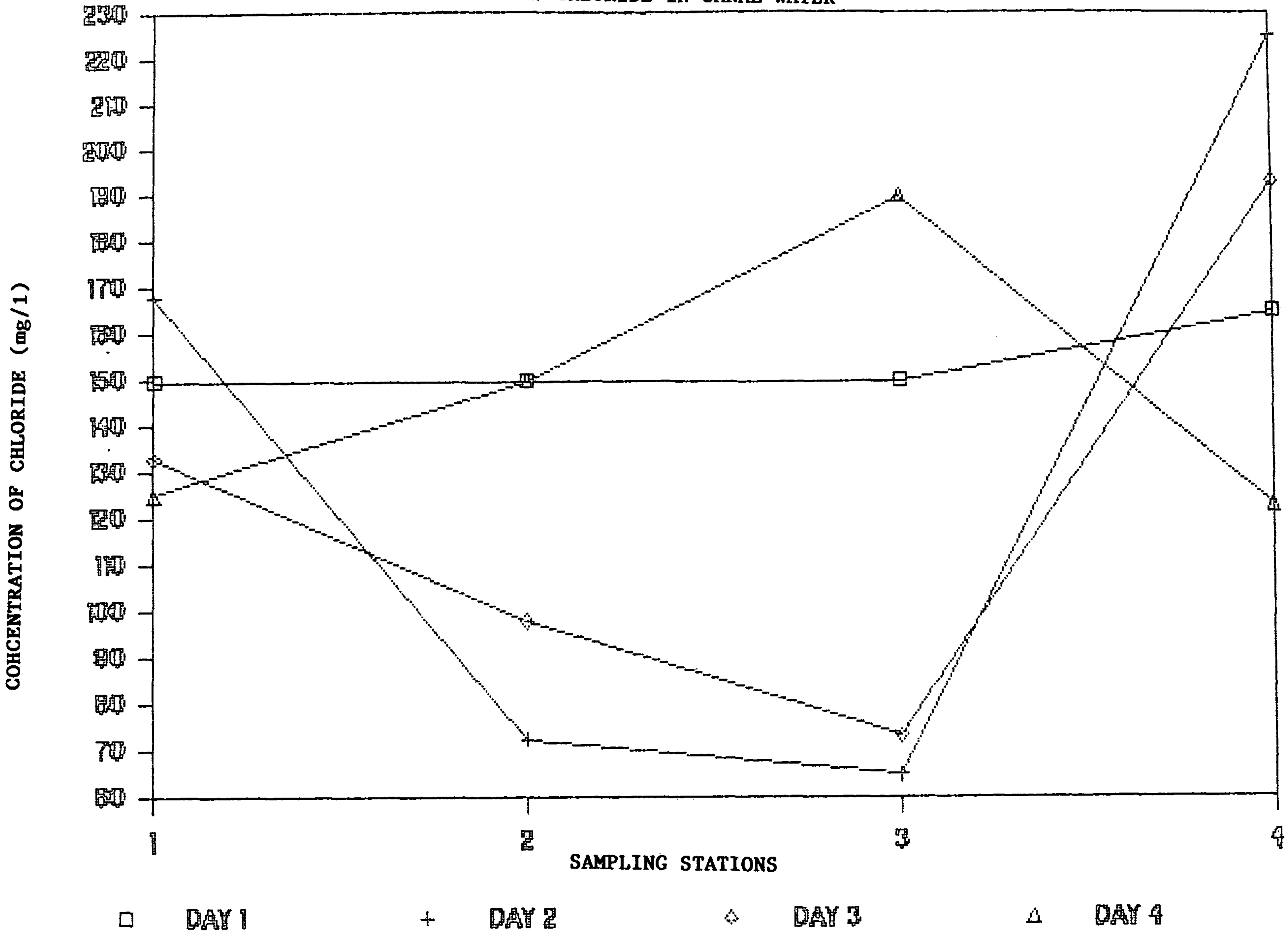
3.3 CHLORIDE

The fluctuation of chloride ion in canal water with respect to sampling points and days are given in Fig. 7.

The fluctuation of chloride levels indicate the effect of tidal changes. Station 4 which is situated about 300 m beyond the mouth of the Kelani river shows the highest levels of chloride ion concentration except for the last visit. Therefore, the highest salinity levels can be expected from station 4. A gradual increase in the chloride content along the stream was observed in the 1st visit, probably as a result of high rain fall during previous night. Considerably high levels of chloride were observed in the samples collected from station 1 which is the furthest from the sea.. The increase in the level of chloride ion at station 1 as opposed to 2 and 3 may be due to effluent discharges from the garment factory and from the nearby houses.

Chloride in the form of Cl^- is one of the major inorganic anions in water and waste water. The chloride ion concentration is generally higher in waste water than in fresh water. Sodium chloride ($NaCl$) is a common article of diet and passes unchanged through the digestive system. The human and animal excreta could be another source of chloride ions found in canal water.

FIG. 7 VARIATION OF CHLORIDE IN CANAL WATER



3.4 NITROGEN SPECIES

3.4.1 AMMONIA

Variation of ammonia content is presented in Fig. 8. The ammonia content of the canal on the 2nd visit appears to be more or less constant. Higher ammonia contents and greater fluctuations are noted for other visits. Sampling station 2 generally shows higher ammonia levels than other stations.

Ammonia is a common pollutant in rivers and lakes often being associated with organic discharges either of domestic or industrial origin. Therefore, high ammonia levels found in station 2 could be due to dumping of domestic waste material into the canal by the residents of the area.

3.4.2 NITRATE

Nitrate ion concentration given in Fig. 9 and ammonia content given in Fig. 8 appear to hold an inverse relationship. (i.e. as NO_3^- increases NH_4^+ decreases and vise versa).

Nitrification process of polluted water is as

FIG. 8 VARIATION OF AMMONIA IN CANAL WATER

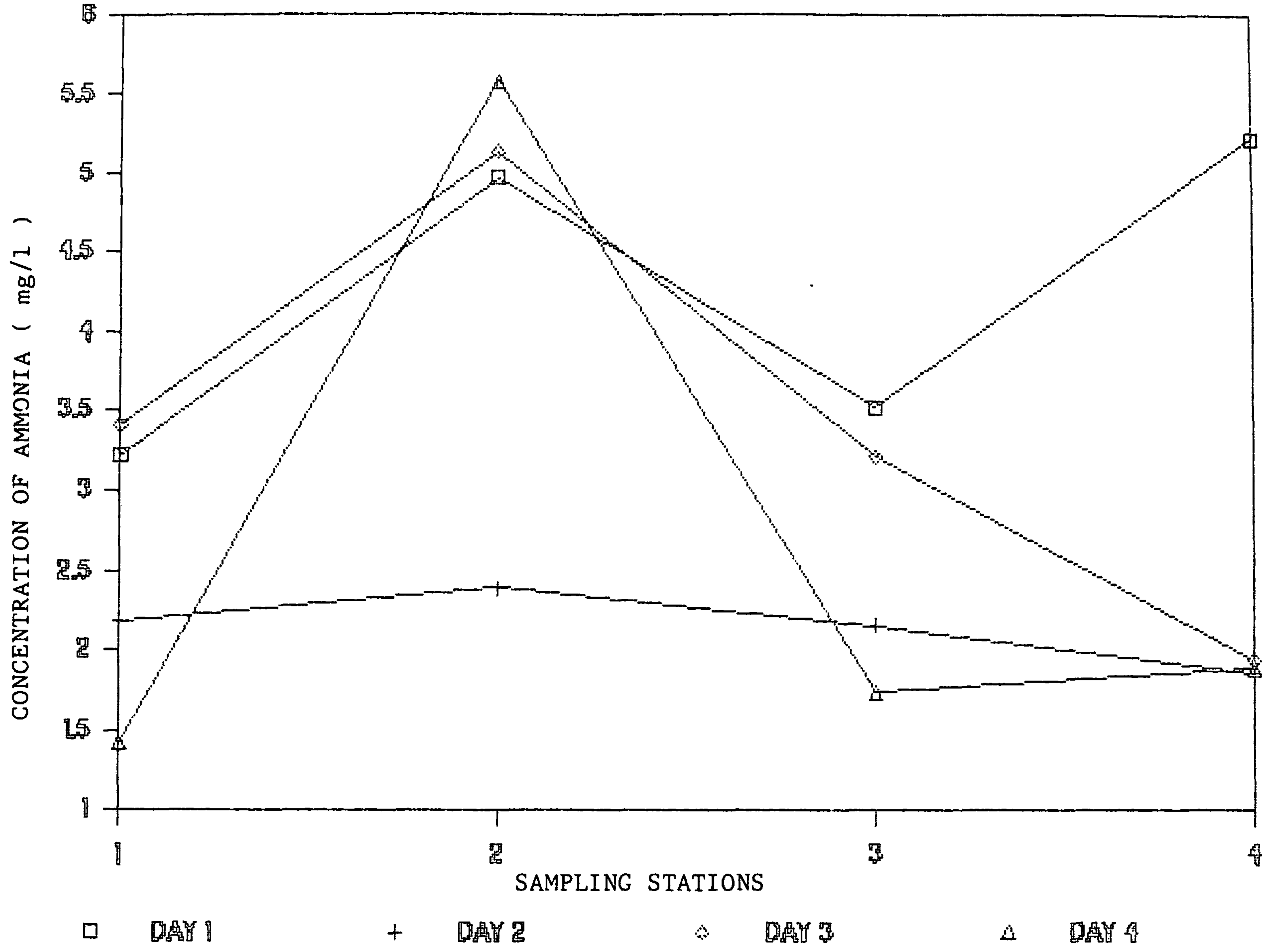
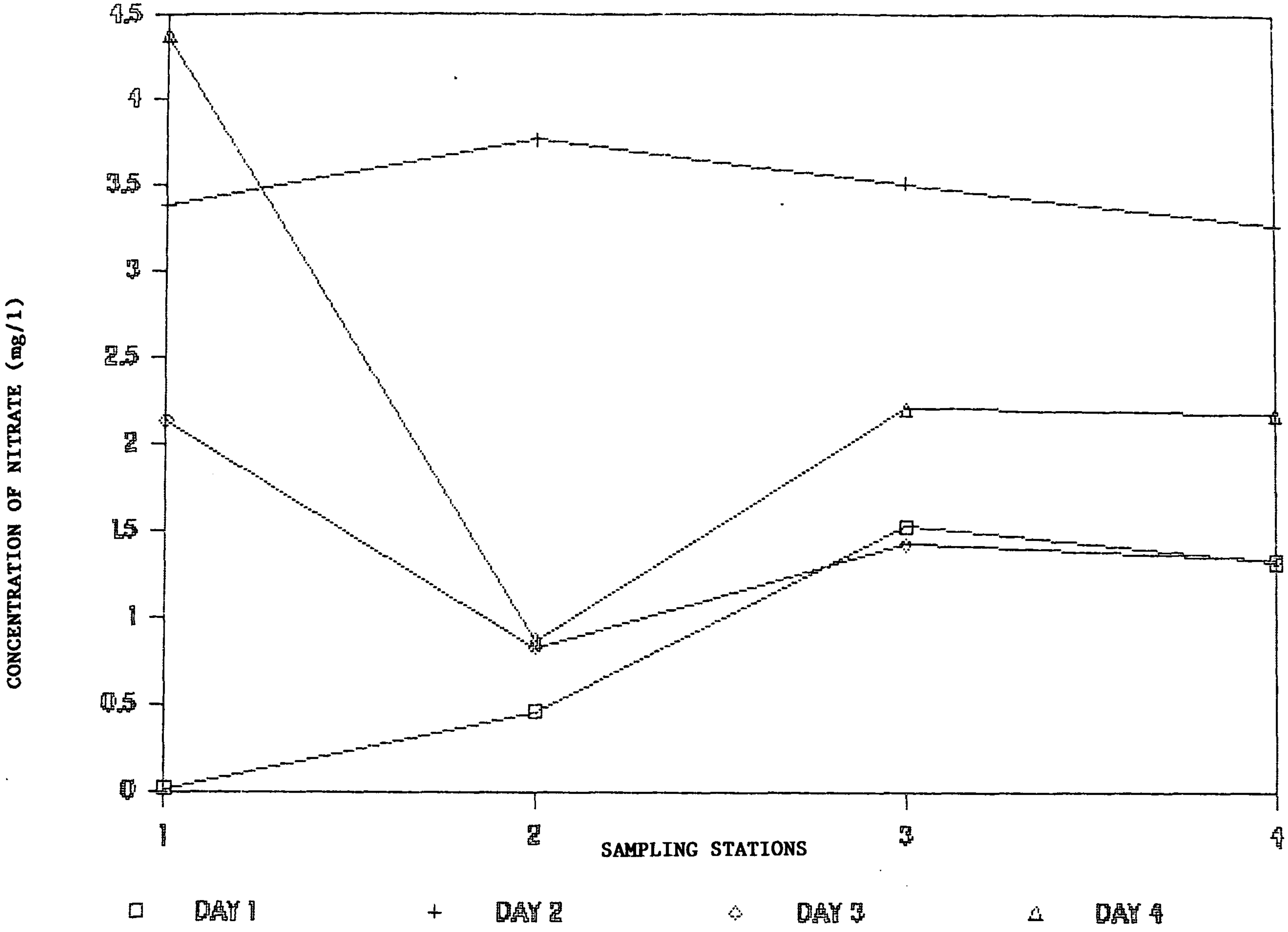


FIG.9 VARIATION OF NITRATE IN CANAL WATER



follows;

$$NH_4^+ \rightleftharpoons NO_2^- \rightleftharpoons NO_3^-$$

Depending on the redox conditions of the canal, the forward reaction (i.e. oxidation) or reverse reaction (i.e. reduction) takes place. NH_4^+ : NO_3^- ratio suggests that the redox condition of the canal was reductive on all sampling days except day 2.

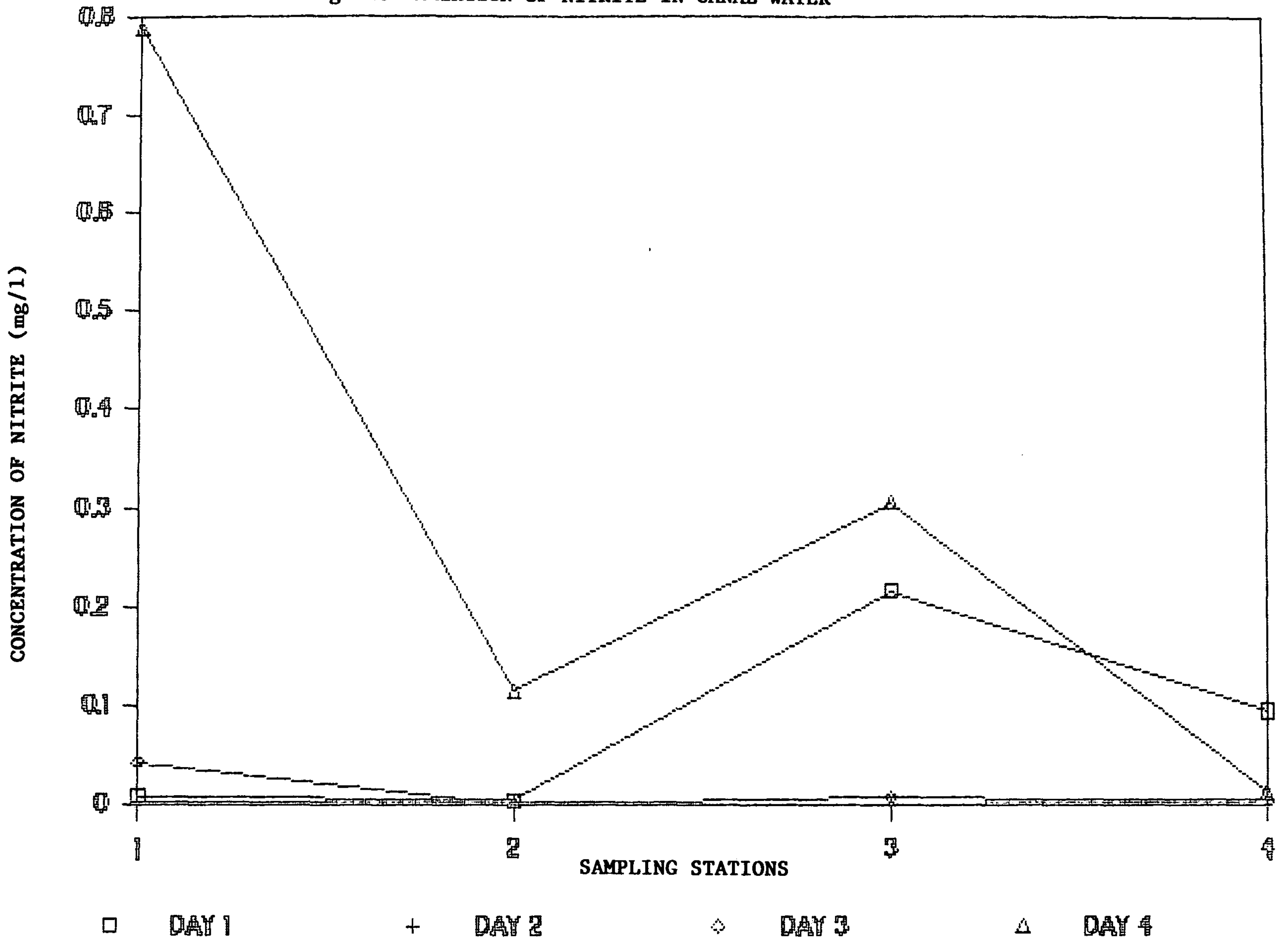
3.4.3 NITRITE ION

Nitrite ion concentration of the canal water appears to be negligible or very small regardless of the sampling point and date of sample collection (except for day 4, station 1) as shown in Fig. 10. This is indicative of rapid conversion of NO_2^- to either NH_4^+ or NO_3^- depending on the redox conditions of the canal.

3.5 OXYGEN CONCENTRATION AND DEMAND

3.5.1 DISSOLVED OXYGEN

Discharge of oxidisable organic and inorganic matter into water results in a reduction of dissolved oxygen concentration. This is a major cause of fig. 10 VARIATION OF NITRITE IN CANAL WATER



environmental pollution. Dissolved oxygen levels can fluctuate diurnally in response to the photosynthetic and respiratory activity of aquatic plants in heavily weeded enclosed waters.

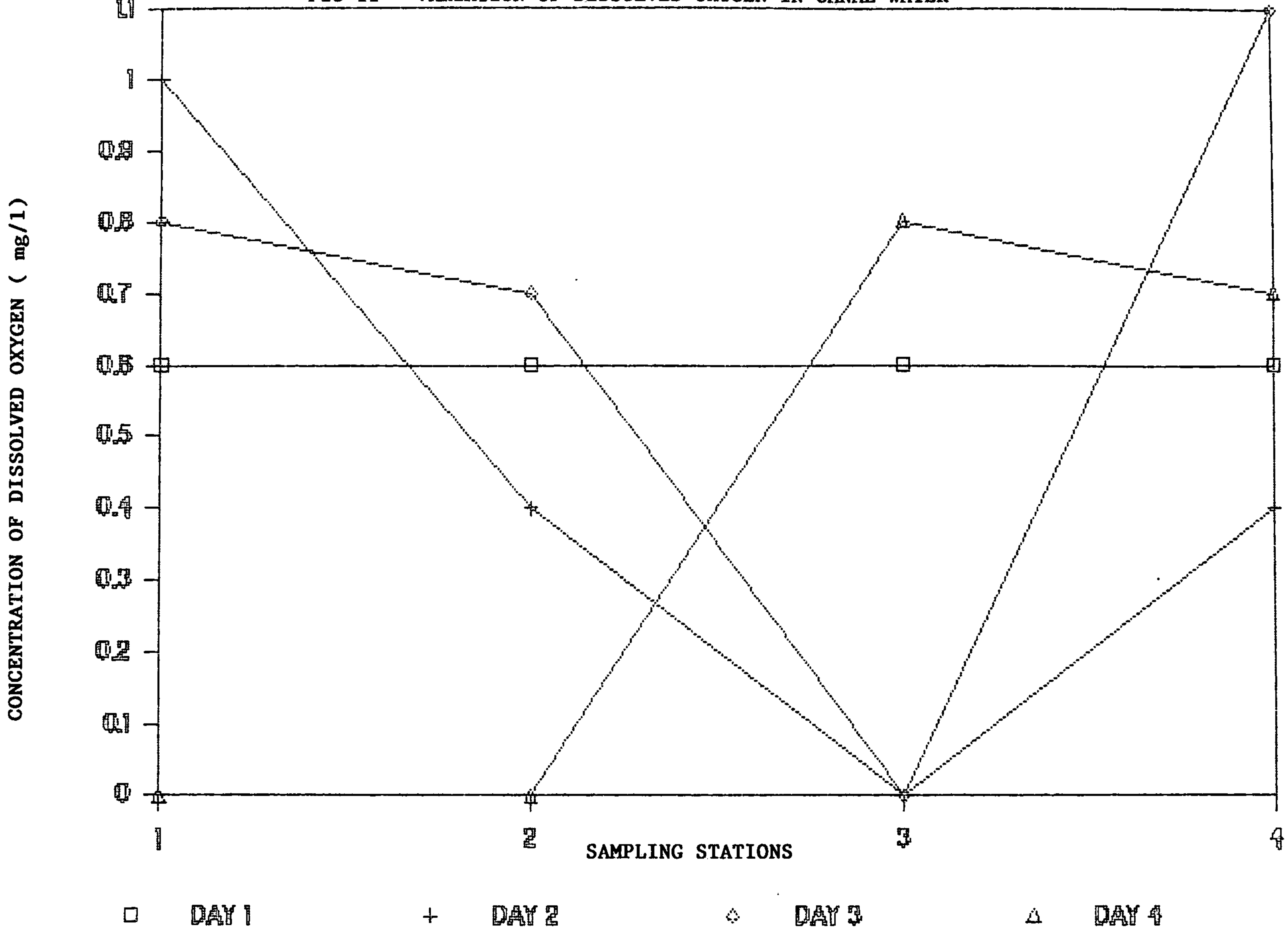
Most waste waters contain more oxygen demanding materials than the amount of DO available in air - saturated water (APHA, 1985).

DO of canal water is given in Fig. 11. In sampling days 2 and 3, sampling station 3 shows anoxyc condition. Therefore the existance of high oxygen demanding substances can be expected in this type of situation. Aerobic organisms cannot tolerate this type of situation. The production of H_2S at this station (as indicative of odour) is therefore due to the anerobic activity of certain microorganisms on organic matter containing Sulphur. In general, DO of the canal is less than 1 mg/l which is considerably lower than that of fresh water. This is a clear indication of the water pollution of the Crow Island mid canal.

3.5.2 BIOCHEMICAL OXYGEN DEMAND

The Biochemical oxygen demand (BOD) determination is an empirical test in which

FIG 11 - VARIATION OF DISSOLVED OXYGEN IN CANAL WATER



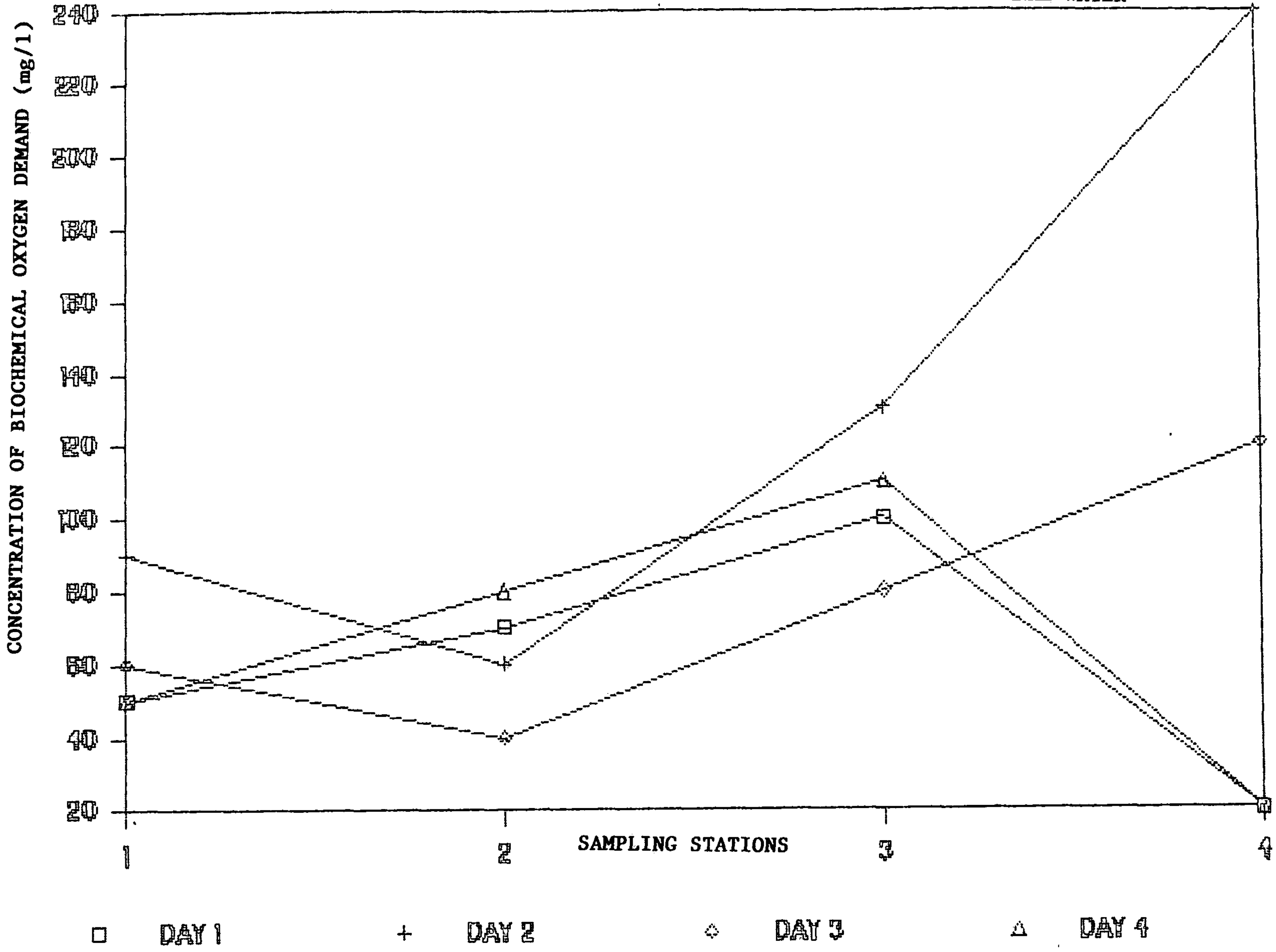
standardized laboratory procedures are used to determine the relative oxygen requirment of waste waters, effluents and polluted waters. The test measures the oxygen required for the biological degradation of organic material (carbonaceous demand) and the oxygen used to oxidize inorganic material such as sulfides and ferrous ion. It also may measure the oxygen used to oxidize reduced forms of nitrogen (nitrogenous demand) unless their oxidation is prevented by an inhibitor.

The BOD of the canal (Fig. 12) was generally below 100 mg/l on all the sampling days. However, unusually high BOD level was observed on day 2 at the sampling station closest to the rever mouth. Variation patterns and the trend of the BOD levels are generally similar for other sampling days.

3.5.3 PERMANGENATE VALUE

The permanganate value is used as a measure of the oxygen equivalent of the organic matter content of water that is susceptible to oxidation by a strong chemical oxident. PV can be related empirically to BOD, organic carbon and organic matter.

FIG 12 - VARIATION OF BIOCHEMICAL OXYGEN DEMAND IN CANAL WATER



On all sampling days except day 2, high permanganate values were noted in the range of 70 to 110 mg/l (Fig. 13). Further the PV was fairly constant along the canal indicating that all the regions of the canal are polluted to the same extent. The high values observed for PV on day 1,3 and 4 suggests that oxidizable waste matter is regularly dumped into the canal.

3.6 PHOSPHATE

Phosphate ion concentration of the canal water shows irregular pattern (Fig. 14). However it appears that phosphate ion content generally falls between 0 - 0.3 mg/l.

3.7 FERROUS ION

Ferrous ion concentration of the canal is very low and the variations of the ion with respect to sampling point and the day of sampling are negligible except for day 4, station 1 (as shown in Fig. 15).

FIG. 13 VARIATION OF PERMANGANATE VALUE IN CANAL WATER

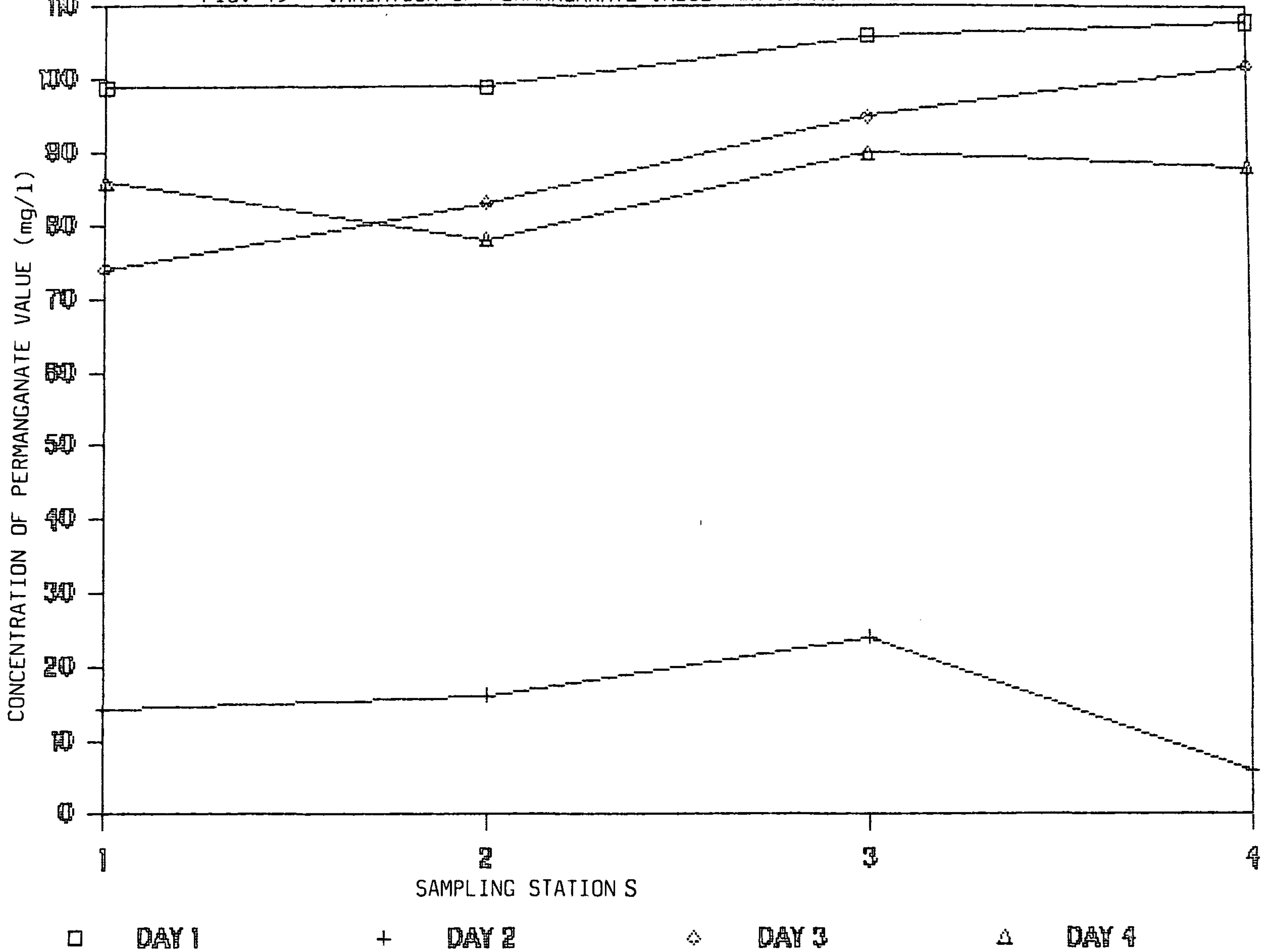


FIG. 14 VARIATION OF PHOSPHATE IN CANAL WATER

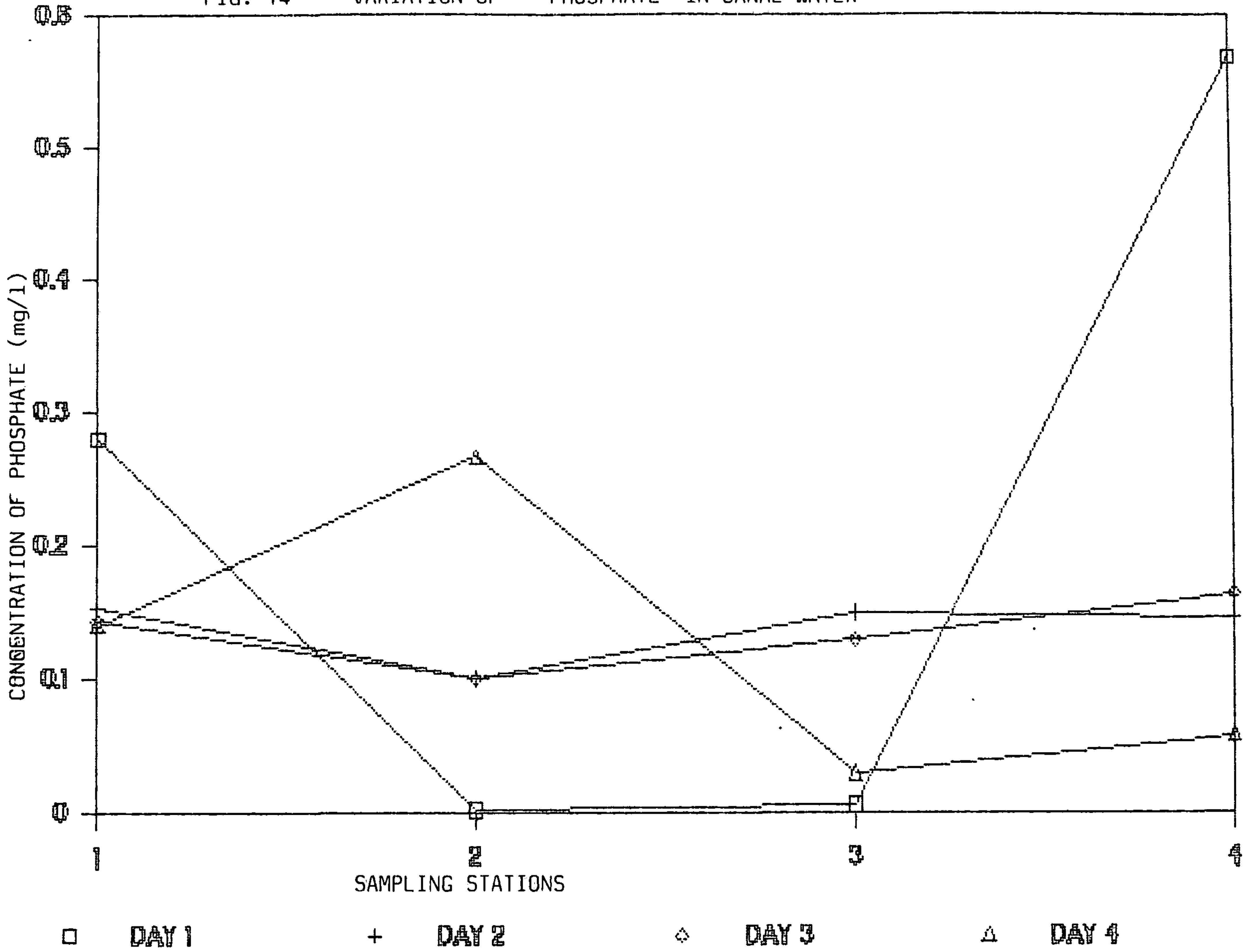
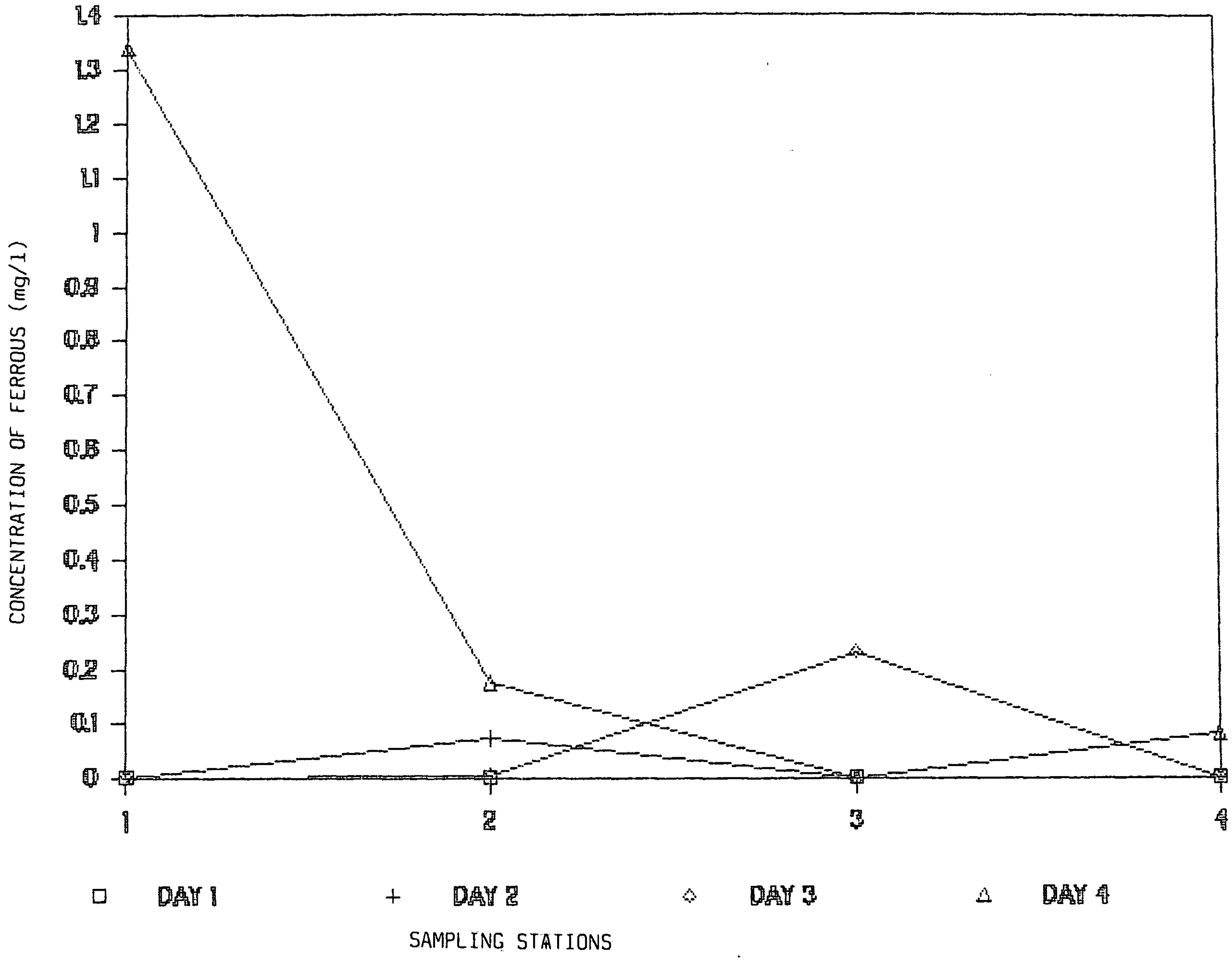


FIG. 15. VARIATION OF FERROUS IN CANAL WATER



4. CONCLUSION

According to the analytical result obtained and field observation made, Crow Island mid canal appears to be polluted with domestic and industrial discharges.

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