WATER RESEARCH AND STUDY CENTER
UNIVERSITY OF JORDAN

PRECIPITATION WATER QUALITY IN JORDAN

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I- INTRODUCTION

In the last few decades increasing interest has concentrated on air pollution and precipitation water quality. The chemistry of precipitation water has gained increasing attention as it was realized that precipitation containing chemicals of various sources can seriously affect plants, soils, surface water as well as manmade structures (Winkler 1976, Groham 1976, Grahn et al, 1974).

In many industrialized countries and their surroundings, acid precipitation damaged up to 40% of the forests (Tam and Cowling, 1976). Also buildings in many countries and especially those in highly industrialized cities were attacked by acid precipitation.

Bhopal / India and Tschernobyle / Russia accidents are considered the most severe air pollution accidents in the eighties of this century. Both affected the precipitation quality and the resultant pollutants were distributed by water to reach lakes, oceans and the groundwaters.

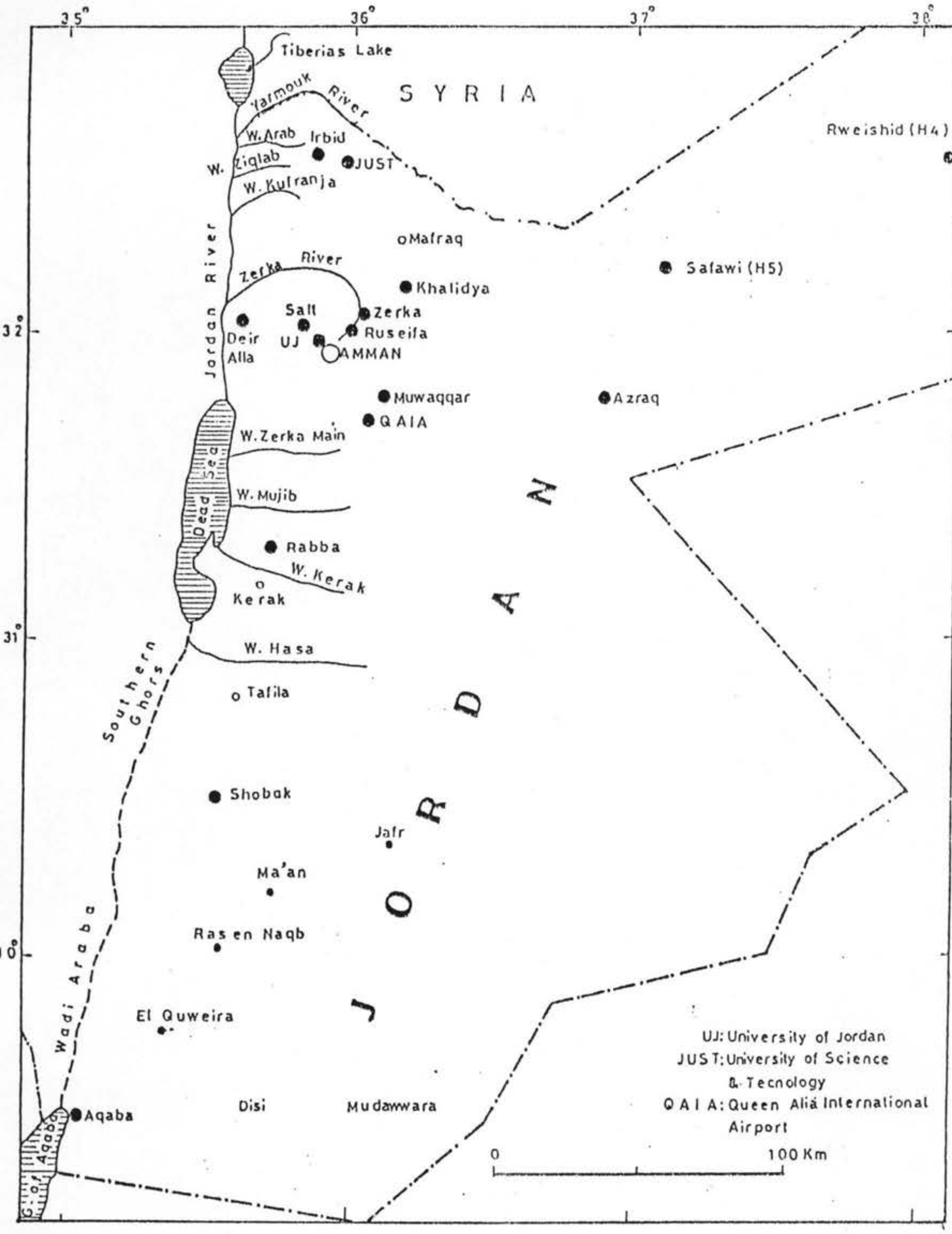
The present Gulf war and the oil spells to the water and the atmosphere will surely be one of the major precipitation pollution events in the nineties of this century which is expected to effect the surrounding areas.

The above mentioned developments and accidents initiated intensive studies concerning the type of chemicals in precipitation water, their concentrations and their effects on soil, plant and manmade structures.

The present study is concerned with the quality of precipitation water in Jordan. It also compares the status of precipitation quality in the various parts of Jordan and discusses the factors affecting the precipitation water quality.

In the course of this study precipitation water of 12 stations was collected and analysed in the last 3 years for the different constituents. These stations are :
Aqaba, Shobak, Rabba, Queen Alia International Airport QAIA, Amman (University of Jordan), Deir Alla, Irbid, University of Science and Technology, Azraq, Zarka, Khalidiya and Muwaqqar, figure (1). Sporadic samples were collected from Ruseifeh, Salt, Rweishid and other places.
The following table shows the elevation, the latitude(N) and the longitude(E) of the different locations;

Station Name	Elevation(m)	Latitude(N)	Longitude(E)
University Farm (Ghore Area)	-230	32 10	35 37
Aqaba Station	2	29 31	35 00
Jordan University	1017	32 01	35 53
Rabba Station	920	31 16	35 45
Shobak Station	1365	30 31	35 32
Rweishid Station	683	32 30	38 12
Al-Safawi	672	32 12	37 08
Zarka Station	555	32 05	36 07
Queen Alia Int. Airport QAIA	715	31 43	35 59
Muwaqqar Station	800	43 46	36 12
Azraq Station	506	32 52	36 54
Khalidiya Station	580	32 05	36 16
Jordan University of Science and Tech.(JUST)	581	32 32	36 08
Salt Station	943	32 10	35 40
Irbid Town	616	32 33	35 51



Figure(1): Location Map of All Stations

The analysed parameters included :

pH-value, Electric conductivity (EC), Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Chloride (Cl), Sulfate (SO_4), Bicarbonate (HCO_3), Nitrate (NO_3), Bromide (Br), Fluoride (F), Iodide (I), Turbidity, Color, and trace metals such as Iron (Fe), Zinc (Zn) and Lead (Pb). Some samples were also analysed for their Oxygen 18 (O^{18}), Deuterium (D) and Tritium (T) concentrations in the laboratories of the Water Authority of Jordan.

II- Methodology and Analytical Techniques

Collection of samples

Samples were collected using porcelain dishes 40 X 60 cm, and 10 cm deep. They were provided with bottom openings to drain the water into glass containers. Dishes and containers were washed with distilled water throughout the collection period after every precipitation event and especially after dust had accumulated in them. The collected samples were filtered using 42 um millipore filter paper and stored at 4 °C in polyethylene bottles after pH, EC and temp. had been measured.

Analytical Techniques

In general, samples were collected from the containers during precipitation events or immediately after they have come to an end. Samples of precipitation during the night were collected in the morning. Only very few samples were collected after a maximum time of 14 hours. Immediately after collection, the pH-value, the electric conductivity and the temperature were measured with digital WTW-equipment. After that, the samples were filtered into polyethylene bottles and analysed for the different parameters using the WRSC analytical methods published in Issue No. 5 (1985) of the Water Research and Study Center, the Standard Methods (Greenberg, et al.,1980) and the Deutsche Einheitsverfahren (1986).

Bromide fluoride and iodide were analysed using low concentration techniques of ion selective electrodes. Trace metals were analysed after concentration by AAS-Techniques (Pye-Unicam SP9).

Chemical analyses

- Electrical Conductivity (EC): PW 9505 Conductivity Meter.
- pH : Beckman Model 3560 digital pH meter.
- Ca^{2+} : Titration with 0.02 N EDTA, indicator muroxide.
- Ca^{2+} & Mg^{2+}: Titration with 0.02 EDTA, Indicator: Eriochrome Black T.
- Na^{+}, K^{+} : Flame Emission Photometric Method.
- $SO_4{}^{2-}$: Titration with 0.02 N EDTA, Indicator Eriochrome T.
- Cl^{-}: Titration with 0.01 N $AgNO_3$, Indicator potassium chromate.
- HCO_3 : Titration with 0.02 N H_2SO_4 , Indicator Mixed bromocresol green and methly red solution.
- NO_3 : Spectrophotometer 5505, (206).

Isotope analyses

1. Tritium : Tritium enrichment in water samples was done by electrolysis. The tritium content of the samples was measured in a Liquid Scintillation Spectrometer (Packard 3255).

The detection limit of the used equipment is 1 Tritium Unit (T.U). The analytical accuracy was around 1 T.U (1 T.U correspond to 0.118 Bq/Kg).

2. Deuterium and Oxygen-18 : They were analyzed by Delta-E Finnigan Mat Mass Spectrometer.

The calibration of the Mass Spectrometer was done by using the international standard; V-SMOW.

2.1 Deuterium: Water samples are converted to hydrogen gas by reduction on zinc in a special preparation line. The hydrogen gas was later used for analyses, the accuracy of measurements is around 1 0/00.

2.2 Oxygen 18: An automatic preparation line is connected directly to the Mass Spectrometer. The CO_2 gas equilibrated with 3 ml of water sample was used for measurements. The analytical accuracy was around 0.15 0/00.

III- Results of Physical and Chemical Parameters

During the precipitation (ppt.) periods 1986/1987, 1987/1988 1988/1989 and 1989/1990, many samples of rain, snow, dew and hail were collected from the stations mentioned above and analysed for their constituents. The results of each station are discussed below.

1- University of Jordan Station

One hundred and forty five samples were collected during the rainy seasons of 1986 to 1990 and analysed for the major constituents. The descriptive statistical analyses are represented in table (1). Due to the large discrepancies in the minima and maxima of each parameter, the fluctuations will be discussed below :

Concentration and fluctuations of the major physical and chemical parameters.

1.1- Amount of precipitation (ppt.)

The highest amount of ppt. in a single rainstorm was 90 mm Figure (2). The maximum amount of ppt. was registered during February 1987; where successive cold polar depressions affected Jordan. Snow fall was recorded five times during the same month. Figure (2) shows the fluctuations in the amounts of ppt. for the period 12th August 1987 to 8th May 1989.

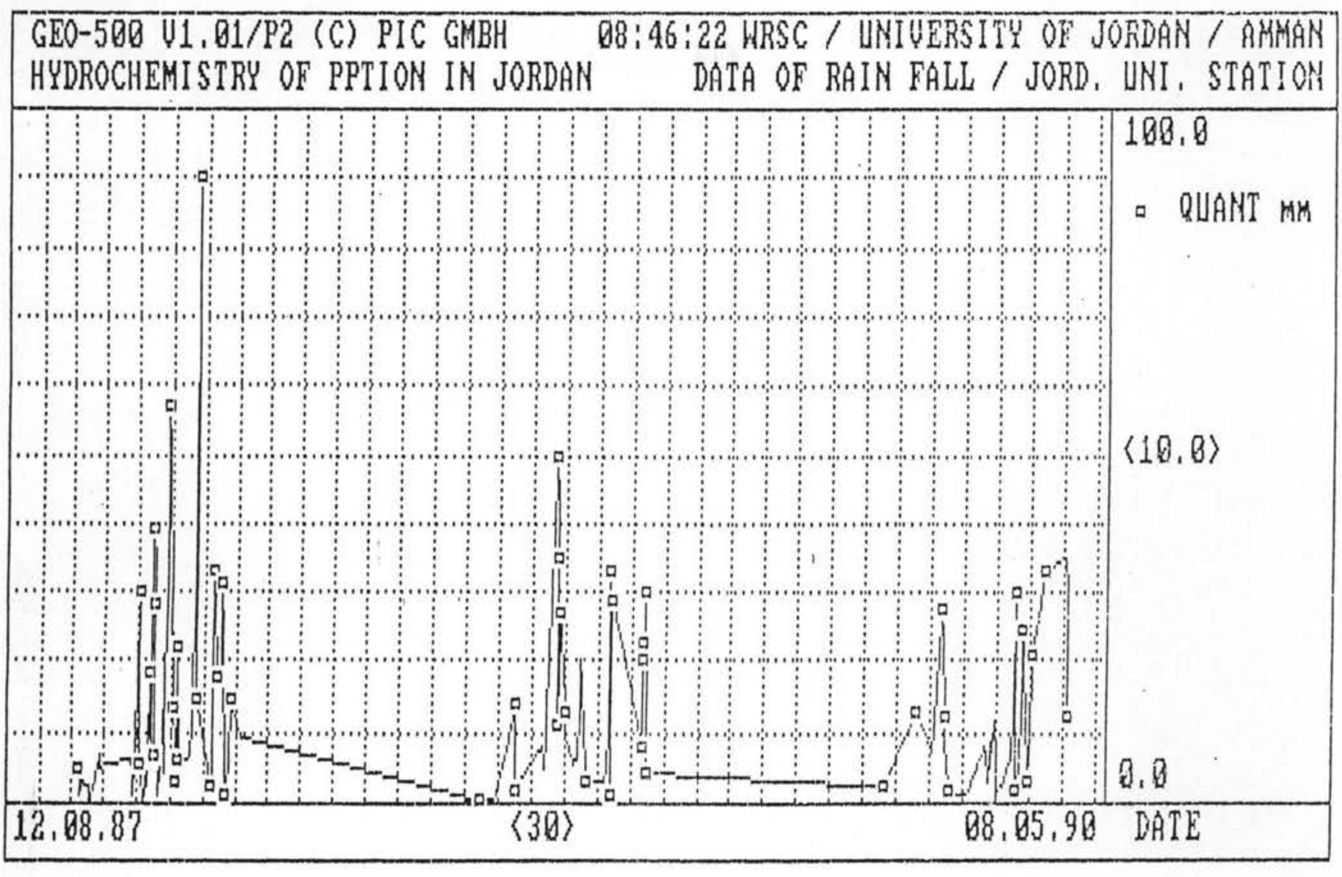
1.2- Temperature °C

The temperatures of 139 samples were measured and were found to range from 0 °C to 21 °C for rain and snow precipitation Figure (3). The large variations in temperature are mainly

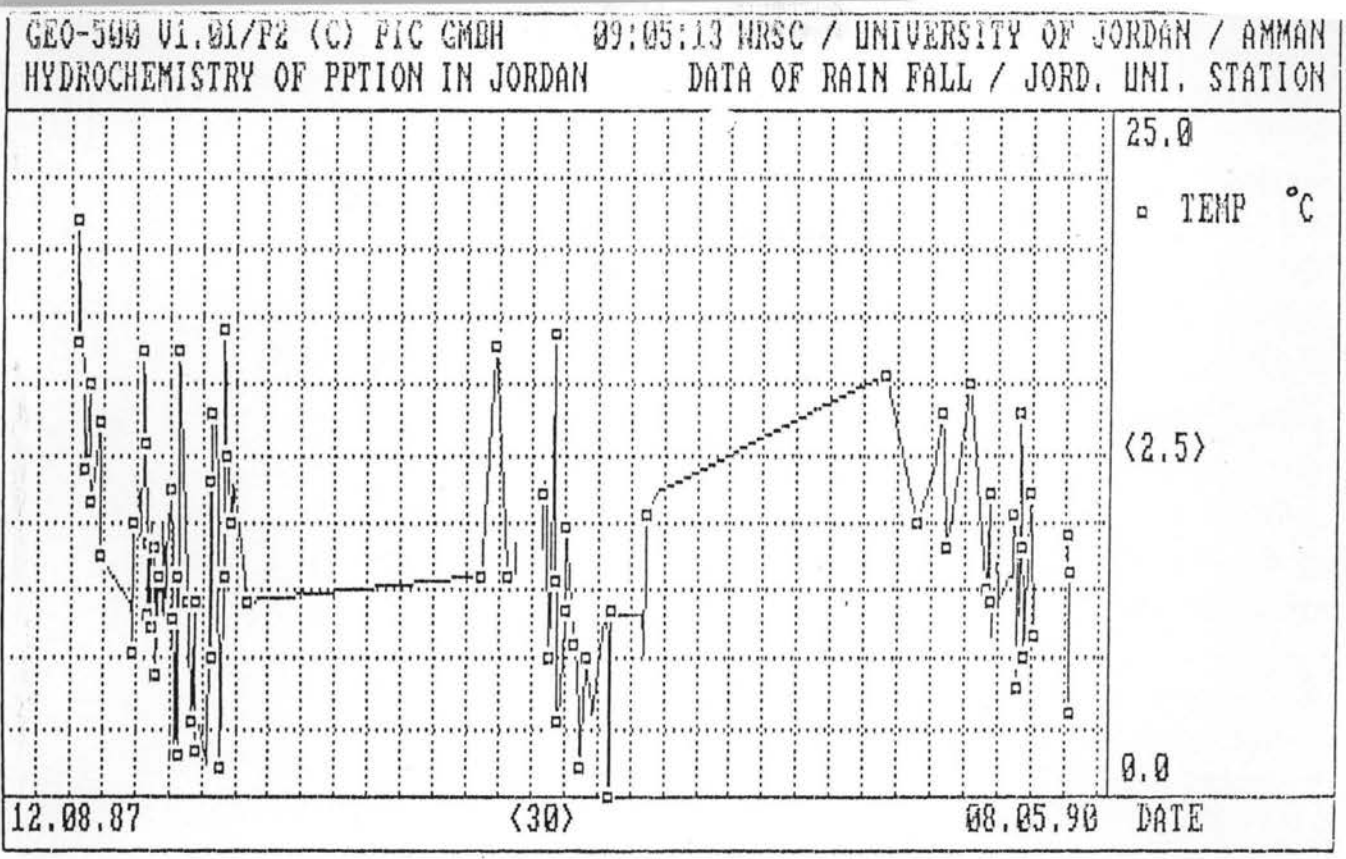
2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32066.0	32965.0	32449.932	291.734
QUANT mm	0.2	90.0	12.958	13.955
TEMP °C	0.0	21.0	8.526	4.358
pH-value	4.85	8.80	7.2099	0.8015
EC µS/cm	9.1	396.0	75.586	70.715
Na meq/l	0.000	2.194	0.18342	0.33191
K meq/l	0.001	0.142	0.02103	0.02480
Mg meq/l	0.000	0.711	0.08799	0.11017
Ca meq/l	0.073	2.444	0.46383	0.41741
Cl meq/l	0.020	1.892	0.25794	0.28918
NO3meq/l	0.001	0.384	0.05179	0.05675
SO4meq/l	0.010	0.901	0.17004	0.17694
HCO3meq/	0.024	1.721	0.27600	0.29948
TC meq/l	0.091	3.960	0.75626	0.70708
TA meq/l	0.091	3.960	0.75578	0.70704
I mg/l	0.000	0.110	0.01210	0.01652
Br mg/l	0.000	0.900	0.04883	0.11044
F mg/l	0.001	0.210	0.04655	0.04703
PO4 mg/l	0.000	0.521	0.12502	0.16346
TOC mg/l	8.10	8.10	8.1000	-0.0000
Li mg/l	0.000	0.070	0.01259	0.01705
TURBIDY	0.0	110.0	10.786	17.748
COLOR	0.0	90.0	15.203	24.042
TDS 104.	0.010	0.450	0.10029	0.10907
TDS 180°	0.000	0.400	0.08271	0.10314
Ag mg/l	0.00000	1.00000	1.994E-02	1.096D-01
TIME hr	7.15	17.00	10.1397	3.4830
Fe mg/l	0.00110	3.00000	2.330E-01	5.503D-01
Cu mg/l	0.00000	0.03950	2.136E-03	5.628D-03
Mn mg/l	0.00000	0.11690	5.170E-03	1.667D-02
Zn mg/l	0.00000	0.84800	5.119E-02	1.278D-01
Pb mg/l	0.00000	0.02070	1.002E-03	2.842D-03
Cr mg/l	0.00000	0.03590	1.178E-03	4.535D-03
Ni mg/l	0.00000	0.05570	2.595E-03	9.624D-03
Sr mg/l	0.00120	0.21700	4.032E-02	5.685D-02

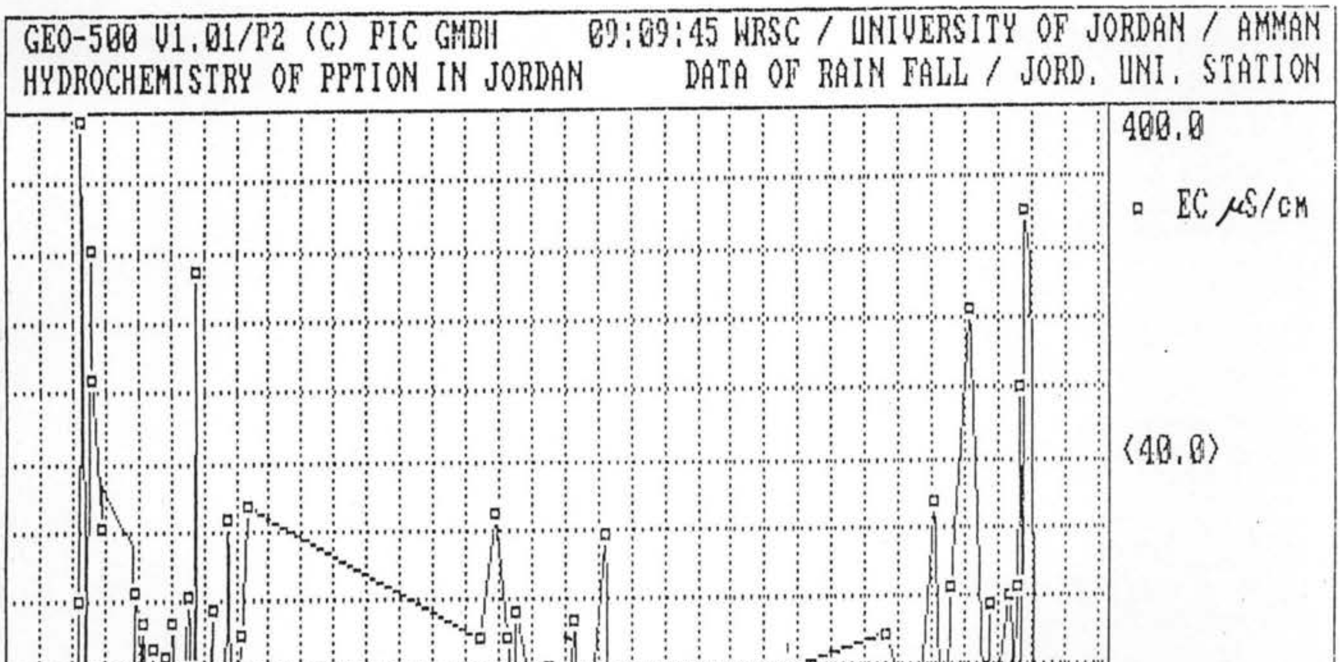
Table(1): Descriptive Statistics for the University of Jordan Station



Figure(2): Fluctuations in the amounts of ppt. for U.J. Station



Figure(3): Fluctuations in Temperature for U.J. Station



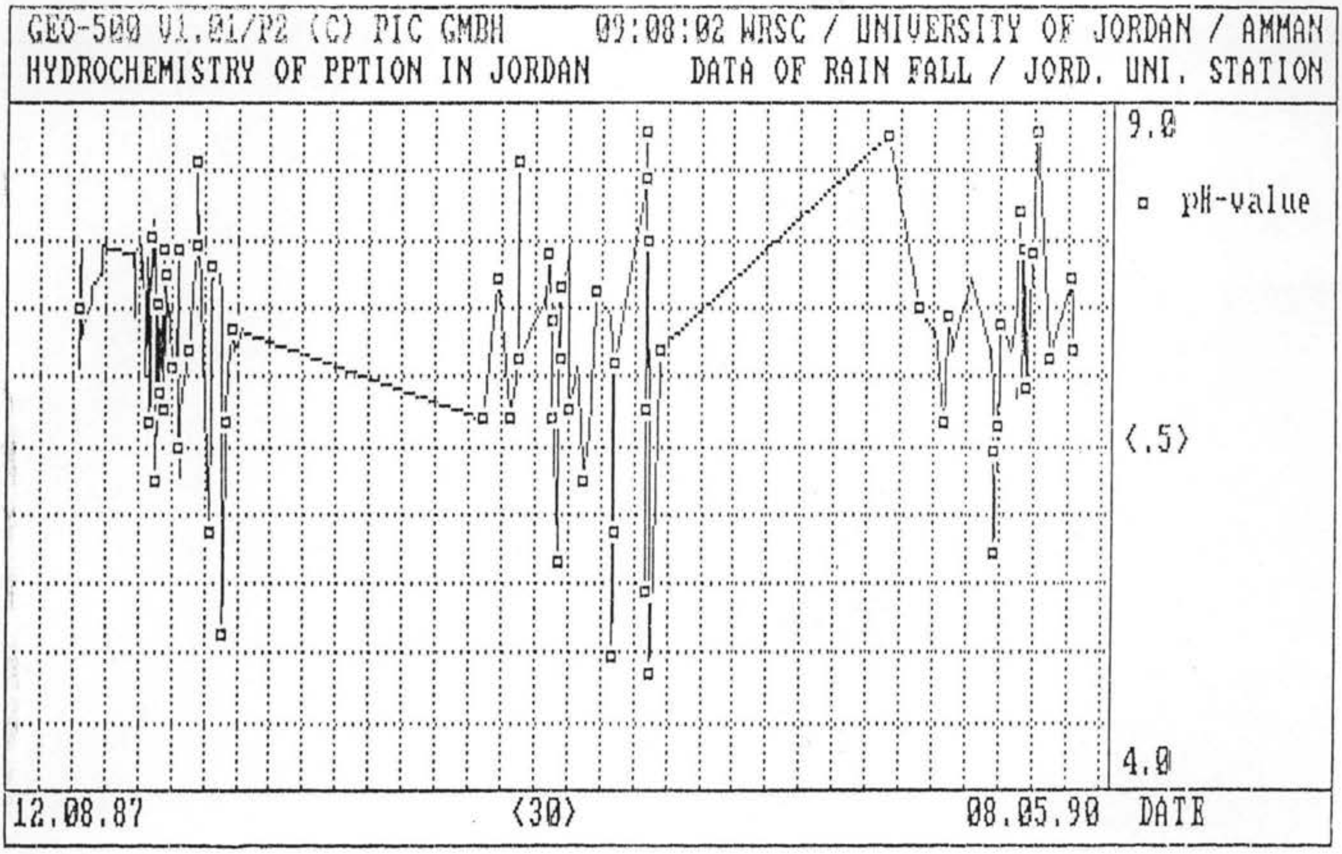
Figure(4): Fluctuations in EC for University Station attributed to the source of depressions invading the country. Whereas the minimum of temperatures were recorded when wet polar or northern depressions affected Jordan. Such depressions are recorded many times yearly in Jordan. The maximum temperature was measured in the first rain sample during the early rainy seasons in the last 3 years, where thunderstorms, and floods affected only the deserts and the northern parts of Jordan (17th October 1987). Generally, the average temperature was 8.5 ± 4.4 °C during the observation period. Hence, Mediterranean fronts are the main depressions which affected Jordan during the rainy season.

1.3- Electric Conductivity (EC µs/cm at 25 °C)

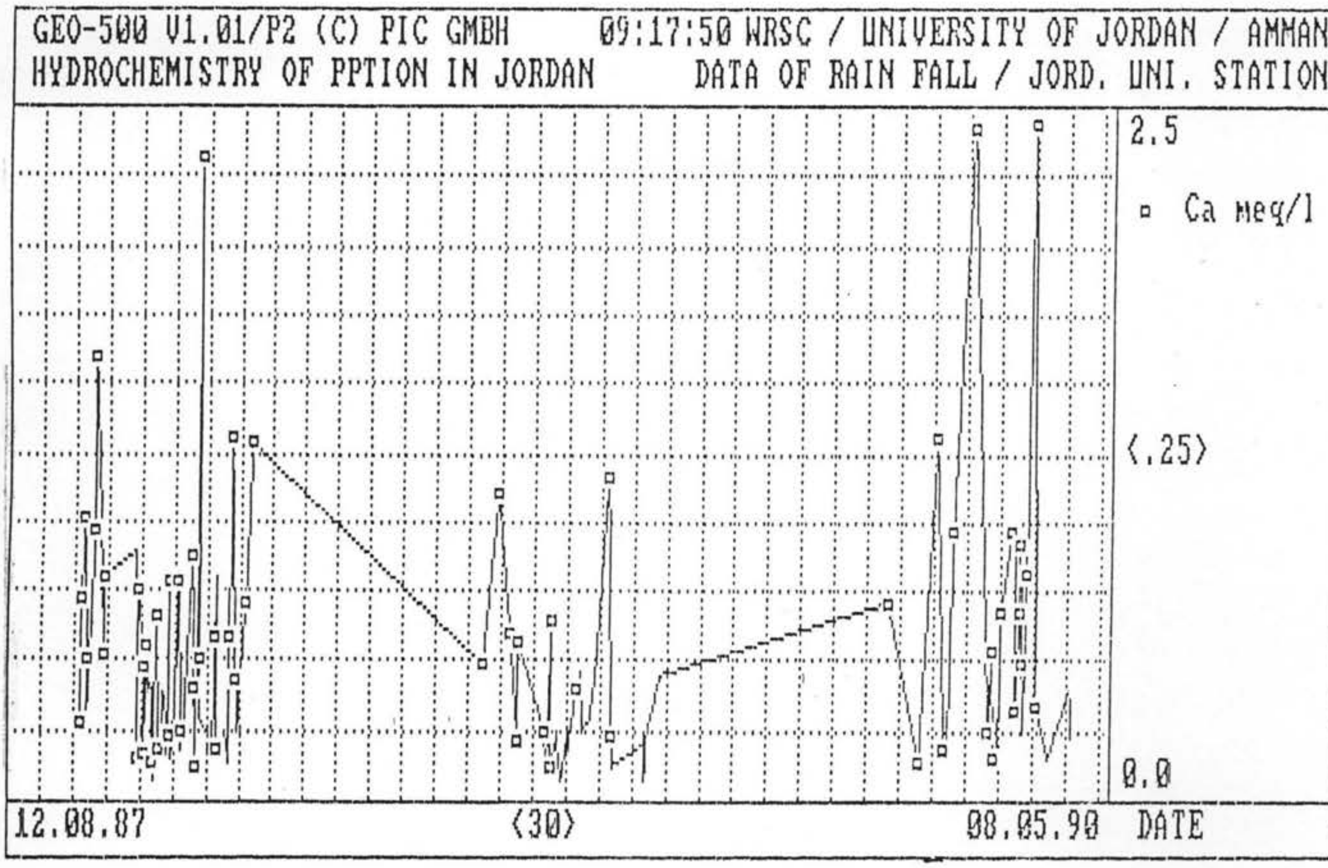
The EC of waters ranged from 9.1 µs/cm to 396 us/cm, figure (4). The lowest value was obtained on the 21st December, 1987 where intense rain and snow precipitated from clear, non dusty, washed atmosphere. The highest value was measured at the beginning of the rainy season of 1987/1988. Lower values (above 200 µs/cm) were also collected, especially when southern depressions affected Jordan or a dusty atmosphere dominated. The arithmetic mean of EC was 75.6 ± 70.7 us/cm of all samples.

1.4- pH - value

The pH-values for this station were measured during or immediately after precipitation events; they ranged from 4.85 to 8.80 figure (5). The lowest value was measured on 24th, February 1988 for the last rain samples collected from an intensive rain storm which continued for many days. During this rain event pH-values started high and decreased to a minimum with time. The



Figure(5): Fluctuations in pH for University Station



Figure(6): Fluctuations in Ca for University Station highest pH-value of this storm event represents the maximum recorded value during the observation period, (20th February. 1988).

The highest pH-values were measured in rain water precipitated from dusty atmosphere accompanying low pressure depressions centered over the Dead Sea. The arithmetical means are 7.21 $\pm$ 0.8. Figure (5), shows the fluctuations of pH-values during the observation period.

1.5- Earth Alkaline Elements (Ca^{2+} & Mg^{2+}).

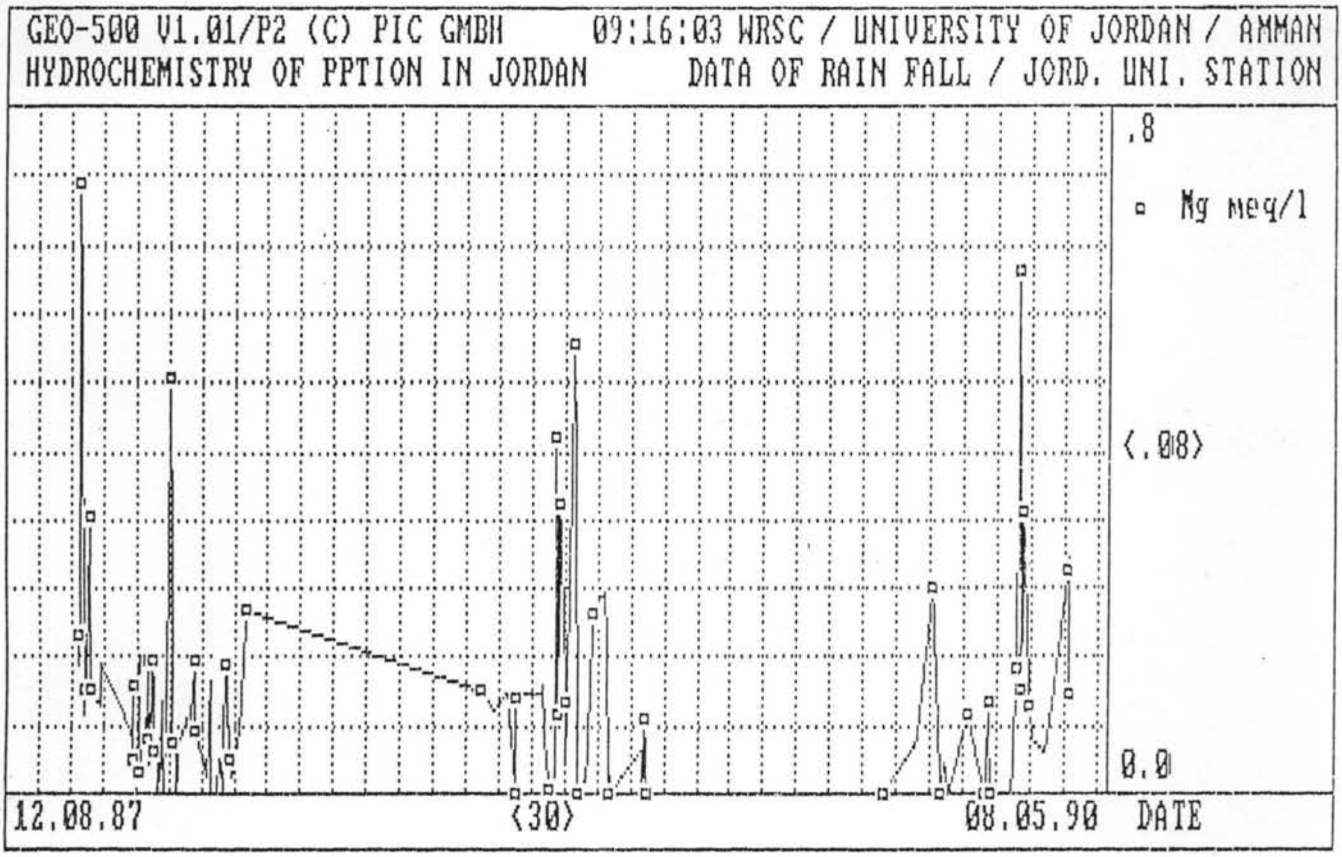
Earth alkaline elements represent the dominant cations in ppt. The calcium and magnesium concentrations in ppt. samples ranged from 0.073 to 2.444 and from 0.00 to 0.711 meq/l for Ca and Mg respectively. Their fluctuations are shown in figures (6 and 7). The highest values present in these figures reflect dusty atmosphere and rain after prolonged non rainy periods in winter.

1.6- Alkaline elements (Na^{+} and K^{+}).

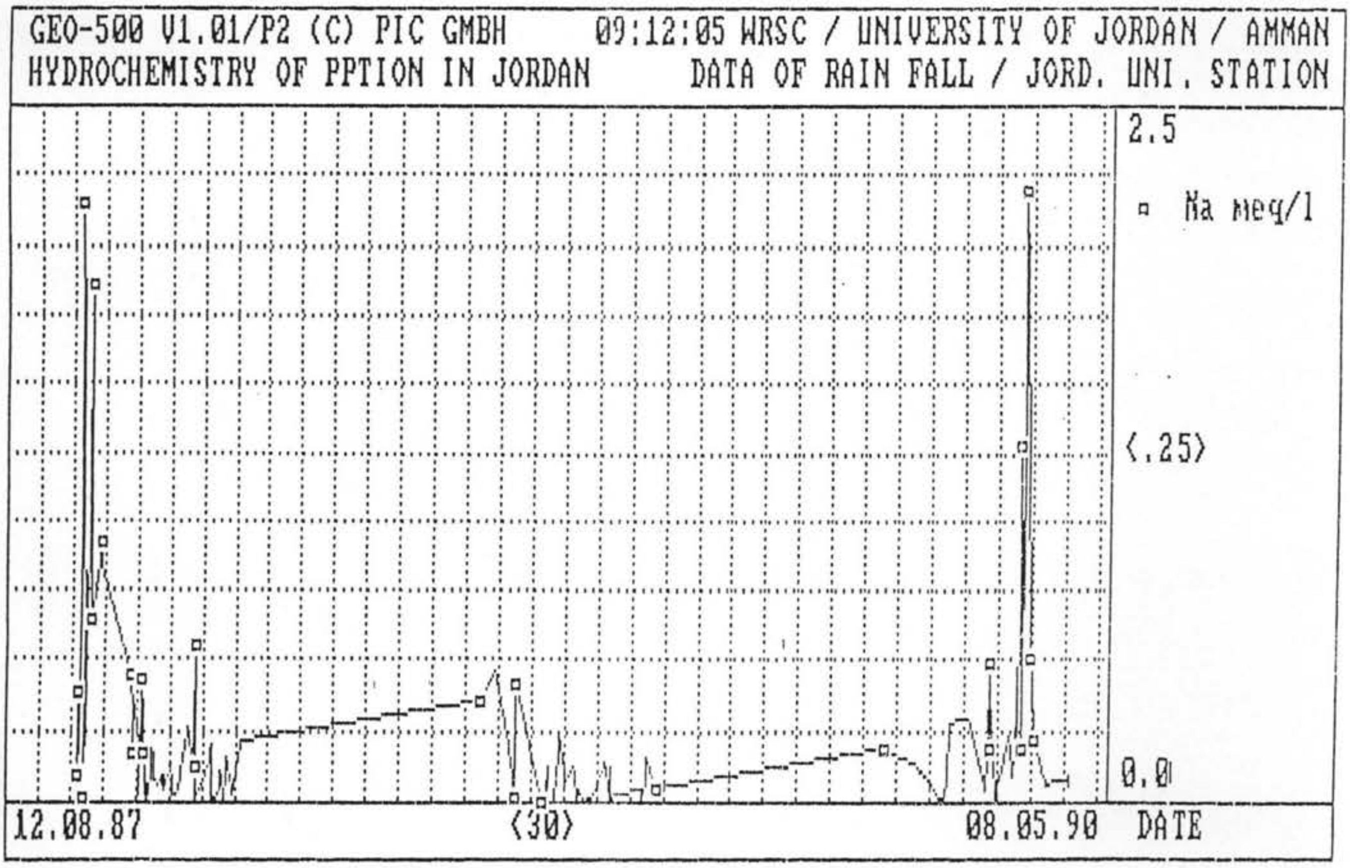
The sodium and potassium fluctuations are shown in figures, (8 and 9). Their content ranged from 0.00 to 2.2 meq/l for sodium and 0.001 to 0.14 meq/l for potassium. The maximum for both elements were bound in rain samples collected during the rainy season of 1987.

1.7- Chloride (Cl^{-})

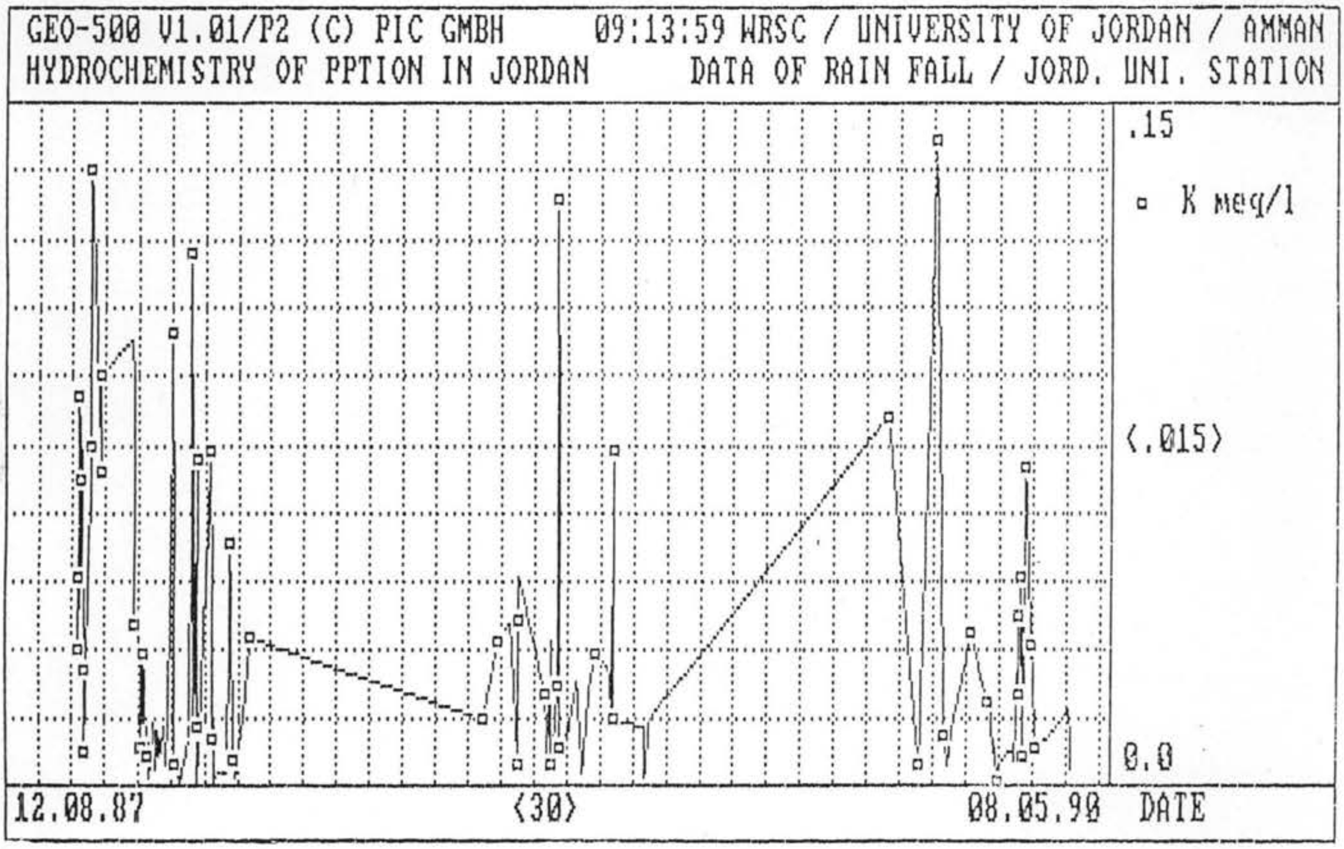
The chloride content varied between 0.020 and 1.9 meq/l figure (10). The highest values were measured in the same samples containing the highest values of Na, K, Mg and highest EC and pH-values.



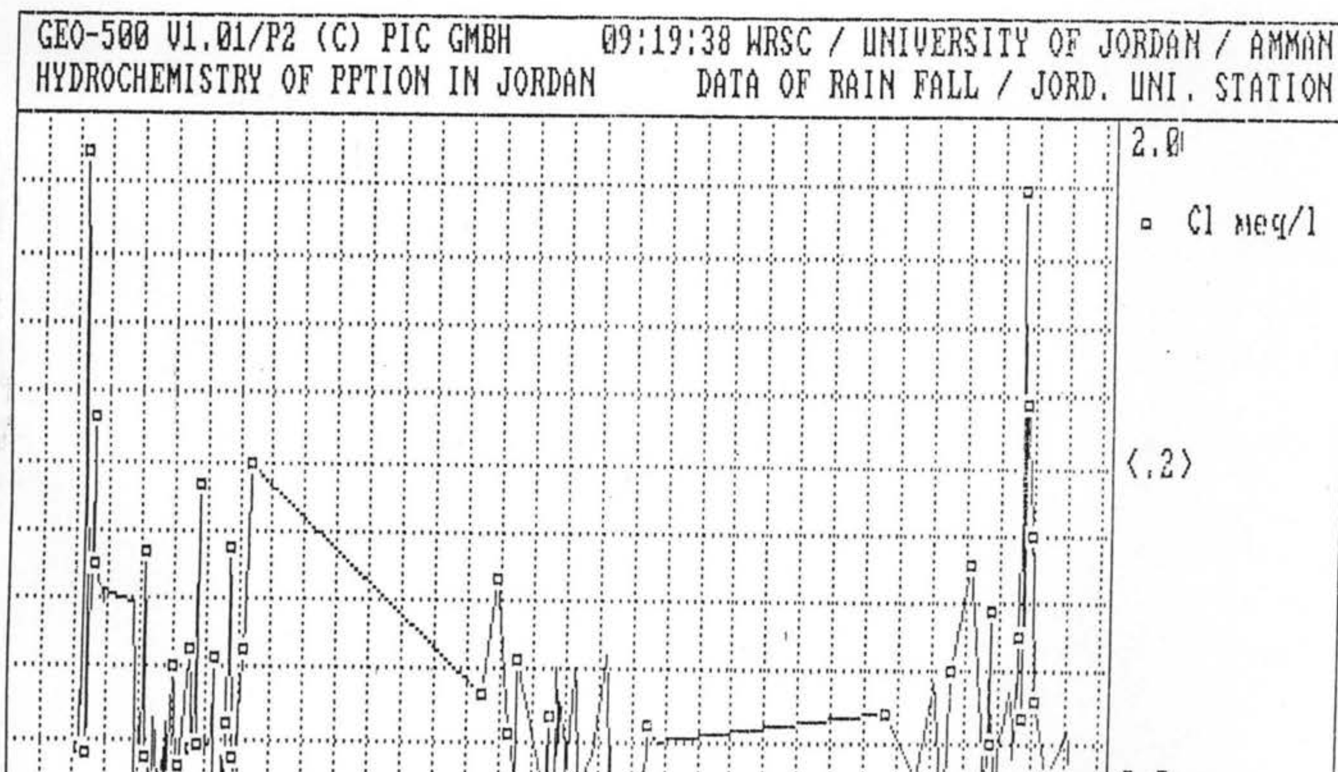
Figure(7): Fluctuations in Mg for University Station



Figure(8): Fluctuations in Na for University Station



Figure(9): Fluctuations in K for University Station



Figure(10): Fluctuations in Cl for University Station

1.8- Sulfate (SO_4^{2-})

The sulfate content ranged from 0.01 to 0.9 mg/l with an arithmetic mean of 0.170 ± 0.177, figure (11). The low sulfate content were restricted to extensive ppt. with low EC values. Whereas, the highest values were found in small ppt. amounts accompanied by dust.

1.8- Bicarbonate (HCO_3^-)

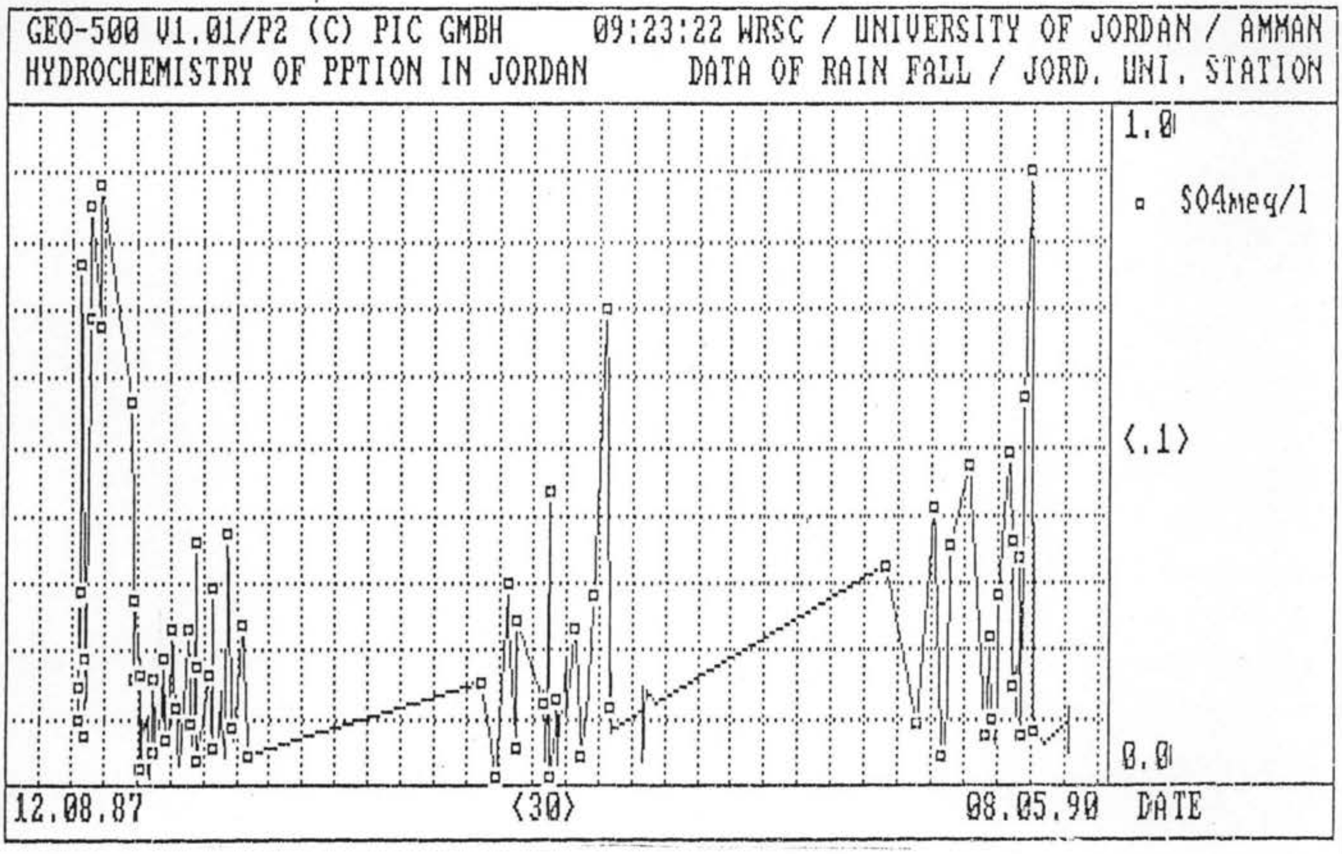
The amount, type, temperature, pH, duration and intensity of ppt. as well as its dust content played the main role in the concentration of bicarbonate. The bicarbonate content ranged from 0.024 to 1.72 meq/l with arth. mean of 0.276 ± 0.3 meq/l, figure (12). The lowest HCO_3 contents were recorded during the coldest months of the rainy season, whereas, the highest values were measured during warmer dusty storms.

1.9- Nitrate (NO_3^-)

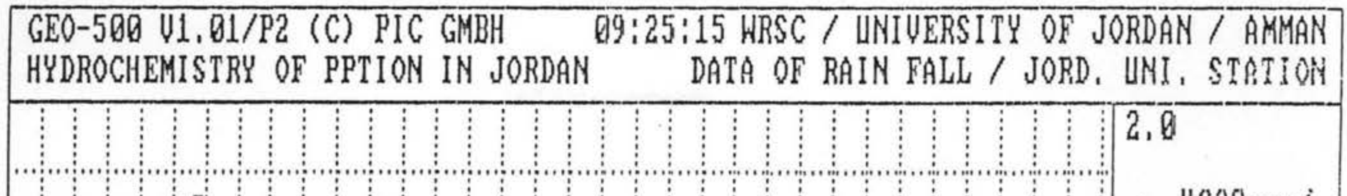
The nitrate contents of ppt. samples ranged from 0.001 to 0.384 meq/l, figure (13). The arth mean was 0.052 ± 0.056. Most ppt. samples contained less than 2 mg/l NO_3. The highest nitrate content was found in rain samples collected at the beginning of thunderstorms.

1.10- Bromide, Iodide and Fluoride (Br^-, I^-, F^-)

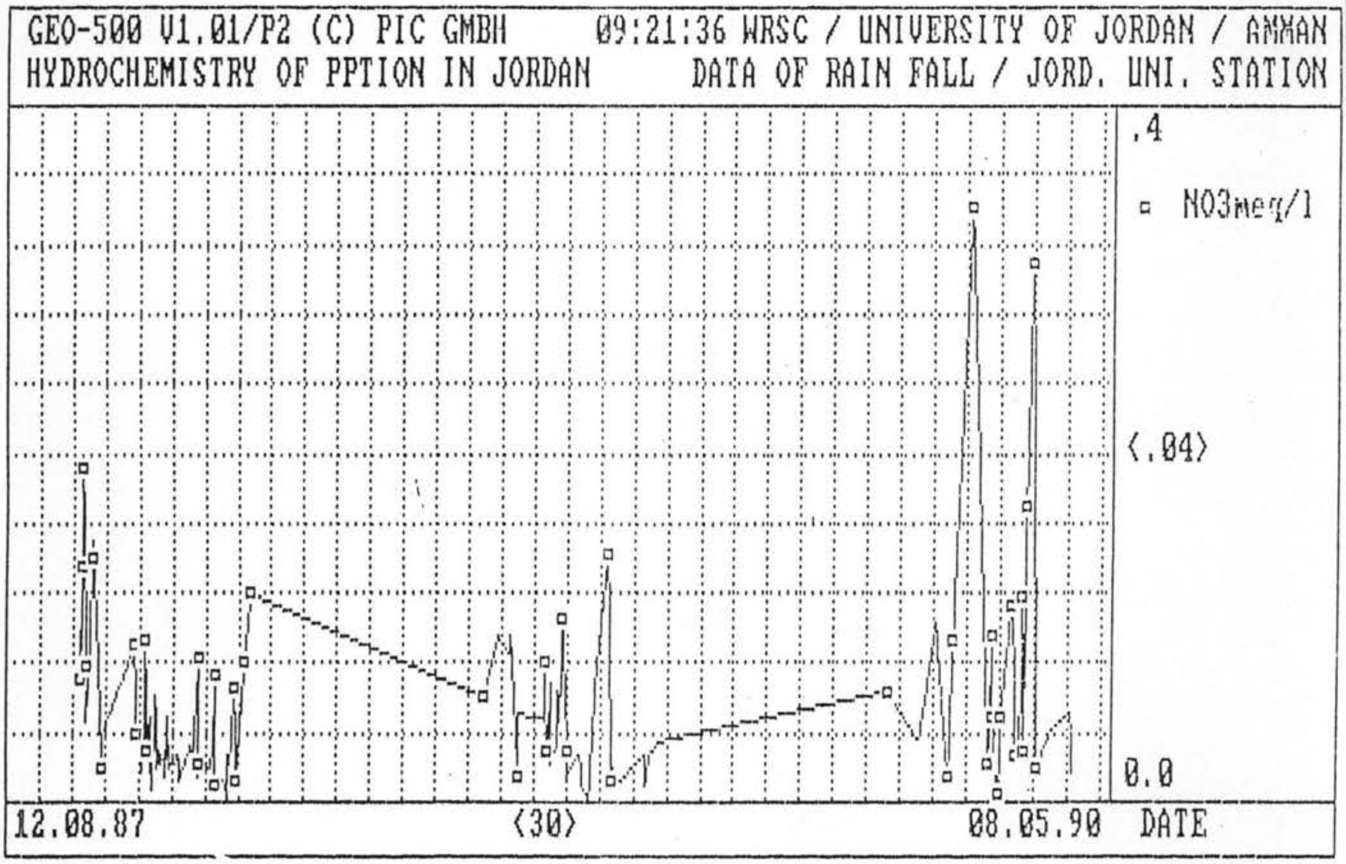
The bromide content ranged from <0.001 to 0.900 mg/l, figure (14). The maximum concentration of bromide was measured twice during the observation period. The first was recorded on 10th of January 1988, when dusty atmosphere prevailed before ppt. The second was measured on the 10th of January 1989; when intense



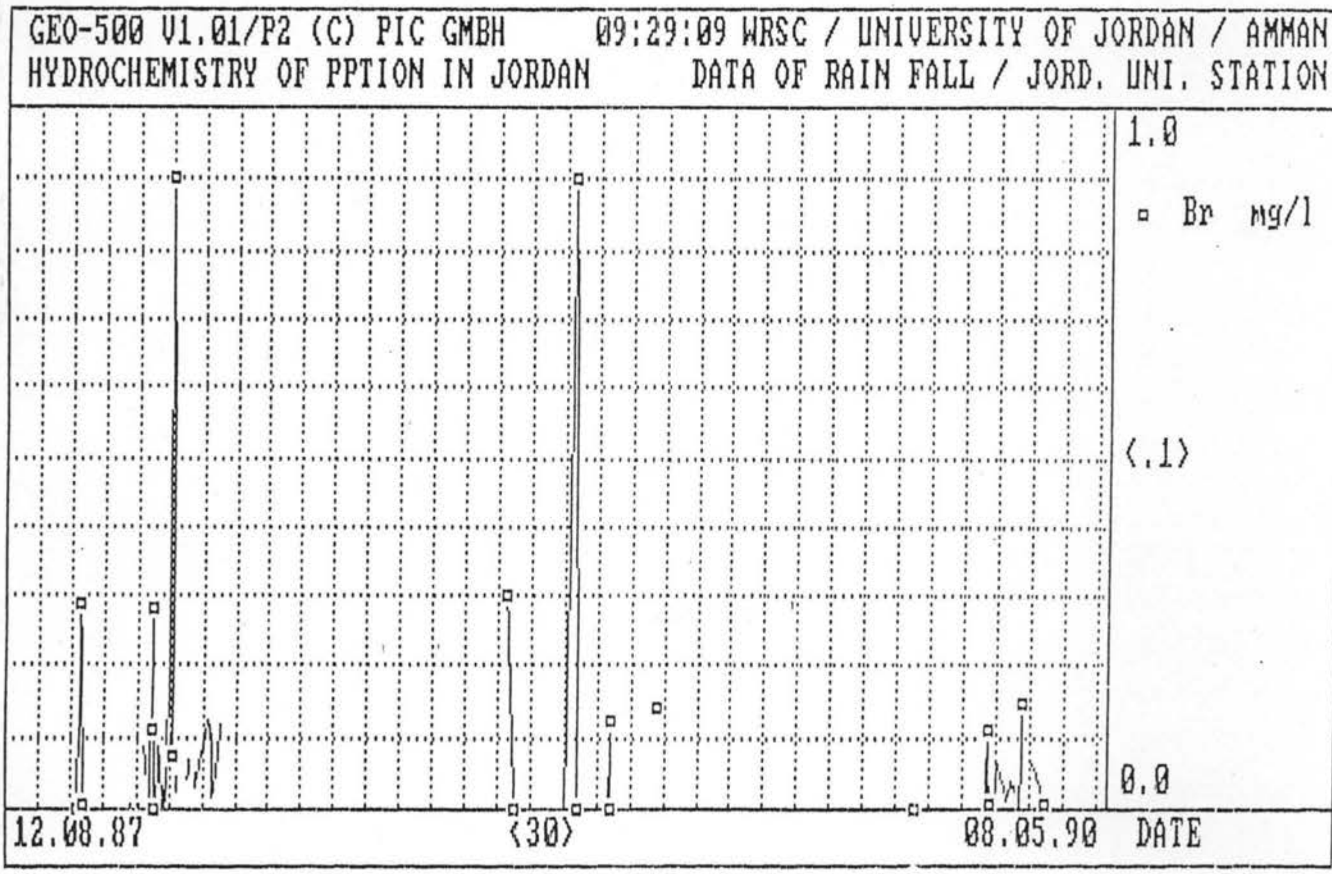
Figure(11): Fluctuations in SO_4 for University Station



Figure(12): Fluctuations in HCO_3 for University Station



Figure(13): Fluctuations in NO_3 for University Station



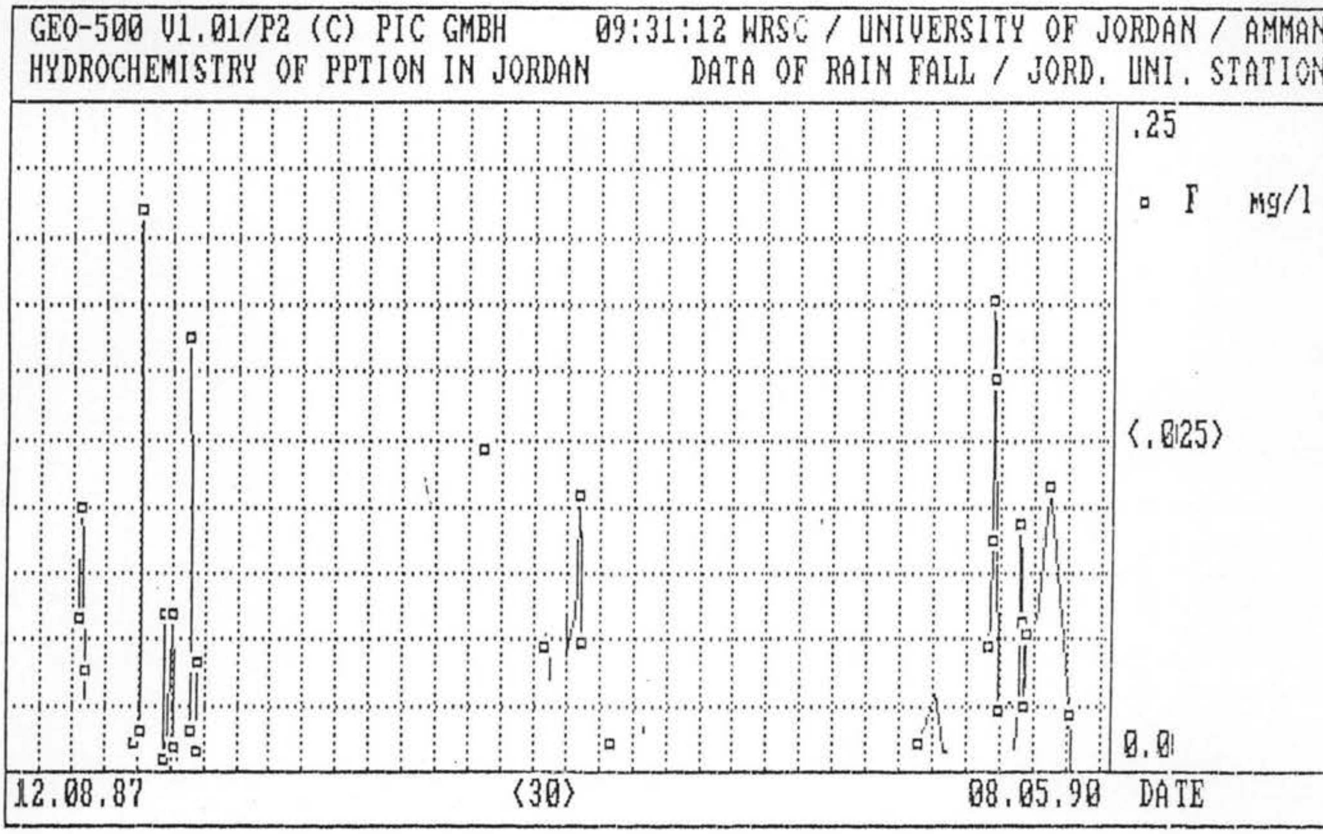
Figure(14): Fluctuations in Br for University Station rain and snowfall dominated. The arth. mean of bromide concentration was 0.049 $\pm$ 0.110 mg/l.

The iodide concentration in ppt. during the observation period ranged between <0.0005 and 0.110 mg/l with an arth. mean of 0.012 $\pm$ 0.0165 mg/l. Most of the rain samples contained iodide with a concentration less than 0.03 mg/l, while sample with higher concentration may be attributed to artificial rainfall experiments conducted by the Meteorological Department. The maximum content of iodide was recorded in rain samples collected from high intensity rainfall storms affecting Jordan; of polar origin.

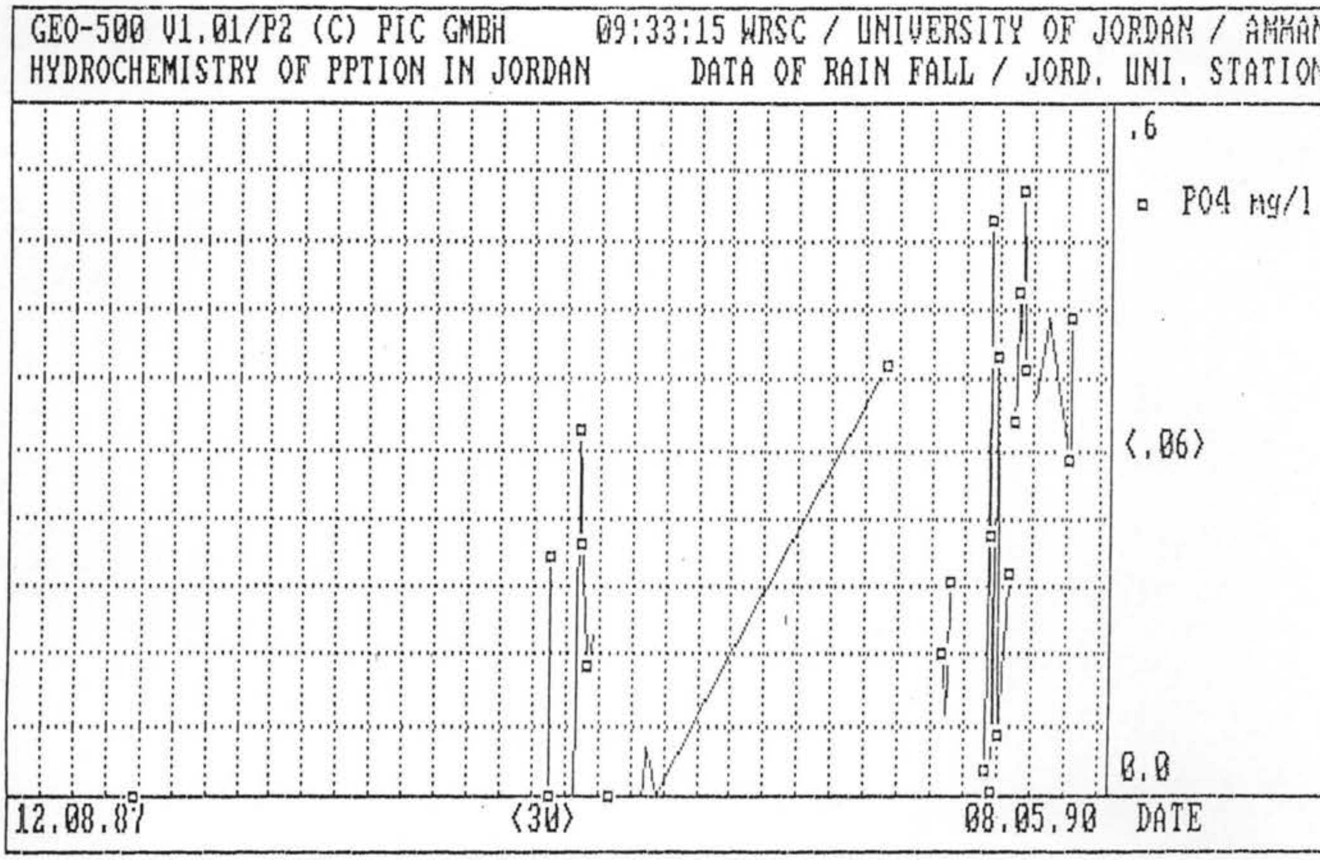
The fluoride content in ppt. ranged between 0.001 and 0.210 mg/l. The arth. mean was 0.047 $\pm$ 0.007 mg/l, figure (15). The maximum content of fluoride was measured when Jordan was affected by polar depressions with successive intense ppt. dominating the country.

1.11- Orthophosphate PO_4^{3-}

Only sixty four samples were analysed for their content of phosphate during the past two hydrologic years (1988/1989 and 1989/1990). The phosphate content ranged between <0.001 and 0.521 mg/l with an arth. mean of 0.125 $\pm$ 0.163 mg/l. This high content of phosphate reflected the type of dust particulates in the atmosphere; most of the dust originated from the north eastern part of Amman where the phosphate deposits and the mines of Ruseifa are located. The variations in the phosphate contents are shown in figure (16).



Figure(15): Fluctuations in F for University Station



Figure(16): Fluctuations in PO_4 for University Station

2- Ruseifeh Station:

Twenty two rainfall water samples from Ruseifeh were collected during the hydrologic years of 1987/1988 and 1988/1989. Descriptive statistics of the different parameters are shown in table (2).

Concentrations and Fluctuations of the Analysed Parameters :

2-1 Amount of rainfall (mm) :

The highest amount of ppt. in a single rainstorm was 52.6 mm figure (17), measured on the 1st of February 1988.

2.2- pH-value

The pH-values of ppt. were measured immediately after the collecting the samples and found to range between 6.87 and 8.42, figure (18). The maximum recorded value was measured on the 5th of December, 1987 while the minimum value recorded, was on the 21st December 1988. The average pH-value of ppt. samples during the observation period is 7.58 $\pm$ 0.39. Generally, most of ppt. water in Ruseifeh was alkaline with the except in of two samples which were slightly acidic to neutral (6.87 and 6.98).

2.3- Electrical conductivity μs/cm

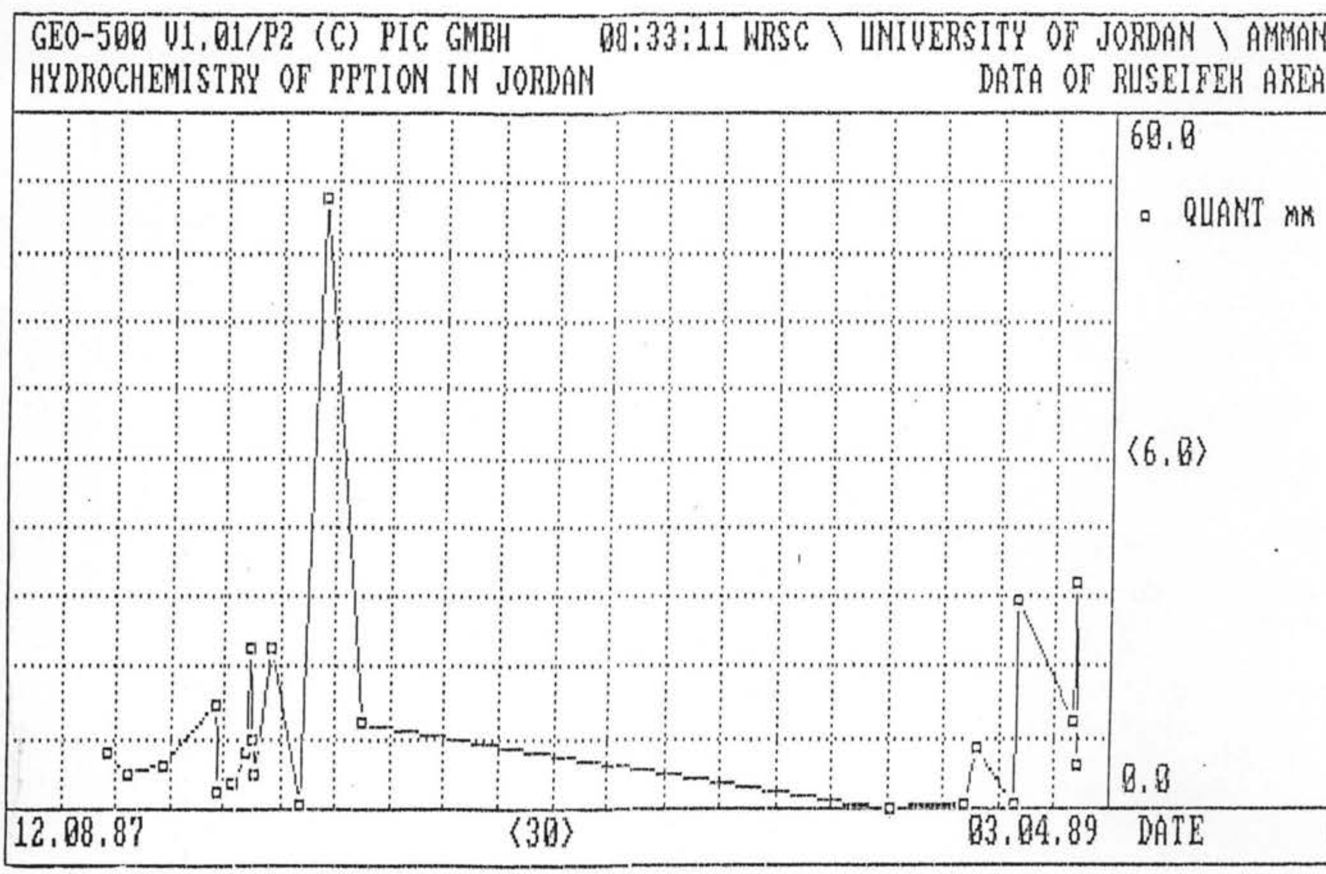
The EC of the collected samples ranged between 66 and 252 us/cm, with an average value of 136 $\pm$ 61.4, figure (19). The relatively high electrical conductivity concerning the minimum value is attributed to the sampling location and the presence of phosphate mines nearby, thus dust particulates are found in the atmosphere all over the year.

HYDROCHEMISTRY OF PPTION IN JORDAN   DATEI A:NEW-RUSF VOM 15.07.15

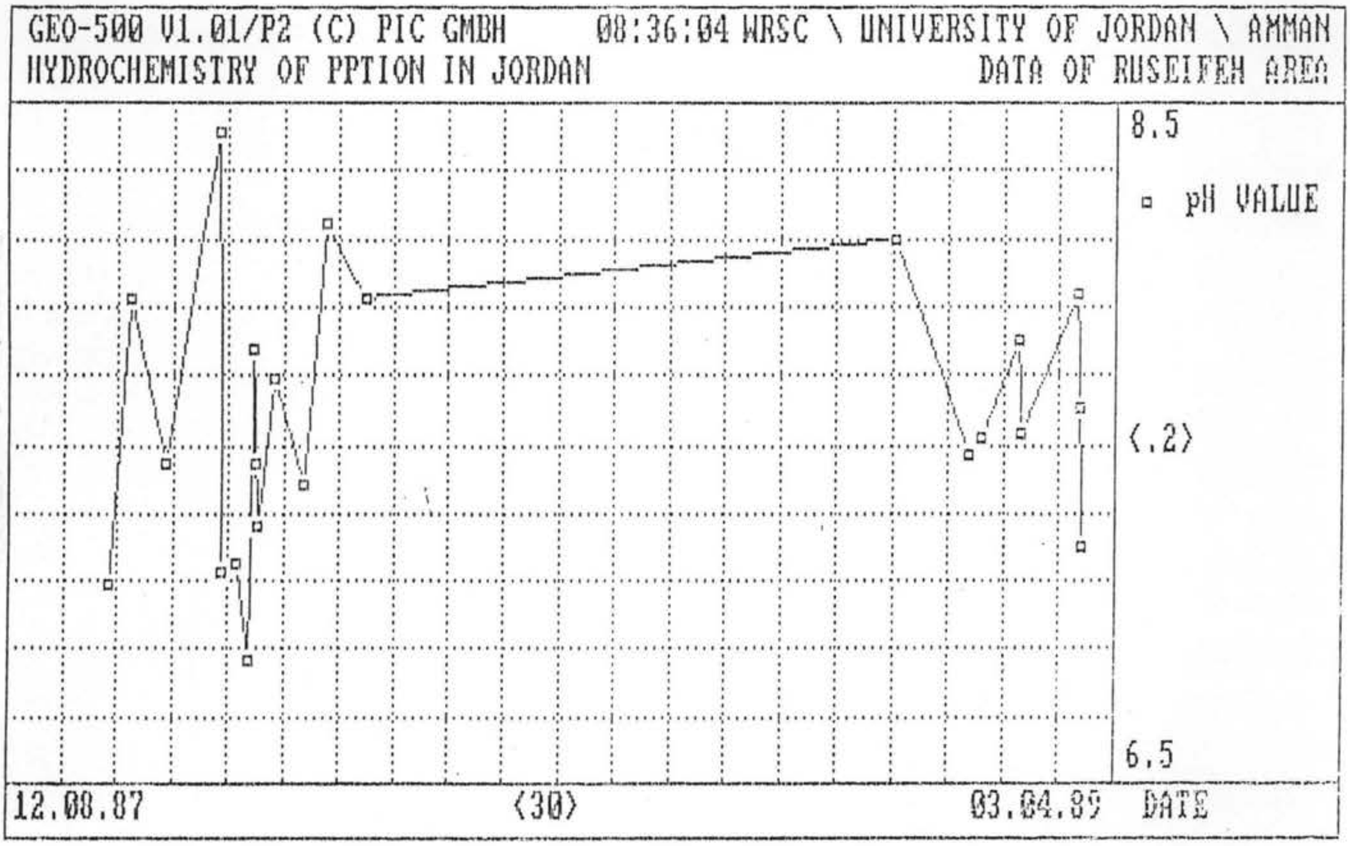
2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32055.0	32582.0	32279.045	209.965
QUANT mm	0.1	52.6	8.141	11.338
TEMP °C	11.2	16.2	14.485	1.949
pH VALUE	6.87	8.42	7.5814	0.3926
EC µS/cm	66.0	252.0	136.418	61.448
Na meq/l	0.015	0.881	0.27162	0.22707
K meq/l	0.004	0.121	0.03031	0.03069
Mg meq/l	0.000	0.783	0.17365	0.18777
Ca meq/l	0.220	1.668	0.88860	0.41521
Cl meq/l	0.147	0.477	0.27495	0.09503
NO3 meq/	0.009	0.129	0.05721	0.03277
SO4 meq/	0.043	1.239	0.44310	0.34568
HCO3 meq	0.214	0.976	0.52727	0.22070
TC meq/l	0.660	2.520	1.36418	0.61448
TA meq/l	0.660	2.520	1.36418	0.61448
I mg/l	0.000	0.023	0.00790	0.00631
Br mg/l	0.000	0.288	0.11283	0.10565
F mg/l	0.010	0.178	0.06038	0.05240
PO4 mg/l	0.177	4.198	1.79943	1.52755
TOC mg/l				
Li mg/l	0.000	0.020	0.00563	0.00961
TURBIDY	0.0	15.0	5.429	6.106
COLOR	2.0	20.0	6.000	6.351
TDS 104°	0.010	0.170	0.06800	0.06797
TDS 180°	0.000	0.050	0.01800	0.02490
Ag mg/l	0.00000	0.00560	5.257E-04	1.250D-03
TIME hr				
Fe mg/l	0.00000	3.07000	5.637E-01	1.003D+00
Cu mg/l	0.00000	0.00880	2.484E-03	3.149D-03
Mn mg/l	0.00000	0.08400	1.472E-02	2.349D-02
Zn mg/l	0.00000	0.63200	1.303E-01	1.759D-01
Pb mg/l	0.00000	0.00360	6.000E-04	1.126D-03
Cr mg/l	0.00000	0.00650	7.000E-04	1.906D-03
Ni mg/l	0.00000	0.00850	1.033E-03	2.605D-03
Sr mg/l	0.02000	0.13000	6.040E-02	4.604D-02

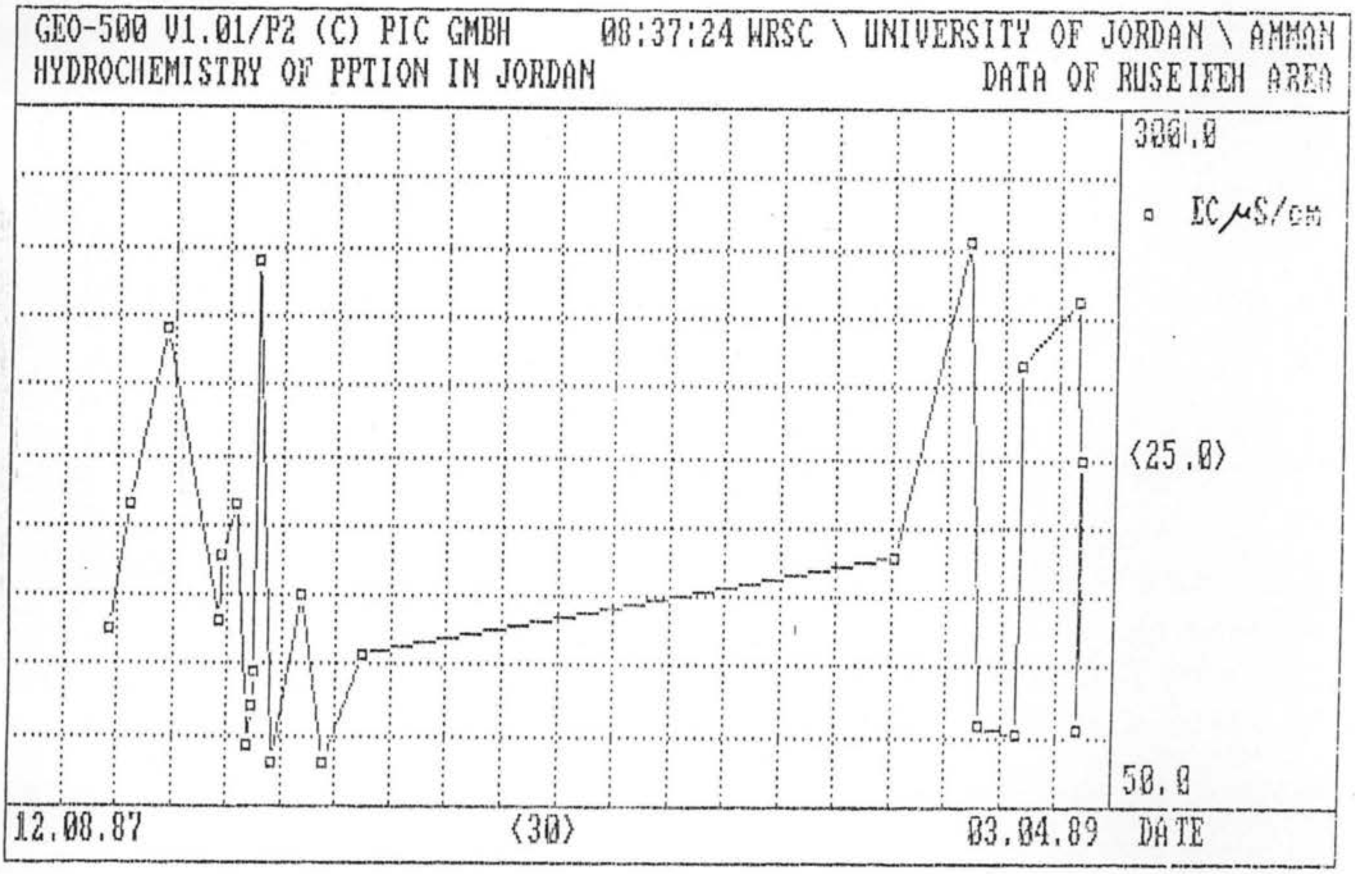
Table(2): Descriptive Statistics for Rusiefeh Station



Figure(17): Fluctuations in ppt. amounts for Ruseifeh Station



Figure(18): Fluctuations in pH for Ruseifeh Station



Figure(19): Fluctuations in EC for Ruseifeh Station

2.4- *Earth alkaline elements Ca^{2+} and Mg^{2+}.*

Calcium and magnesium, ions represented the major cations, with an average percentage of about 88.8 ± 26.7%.

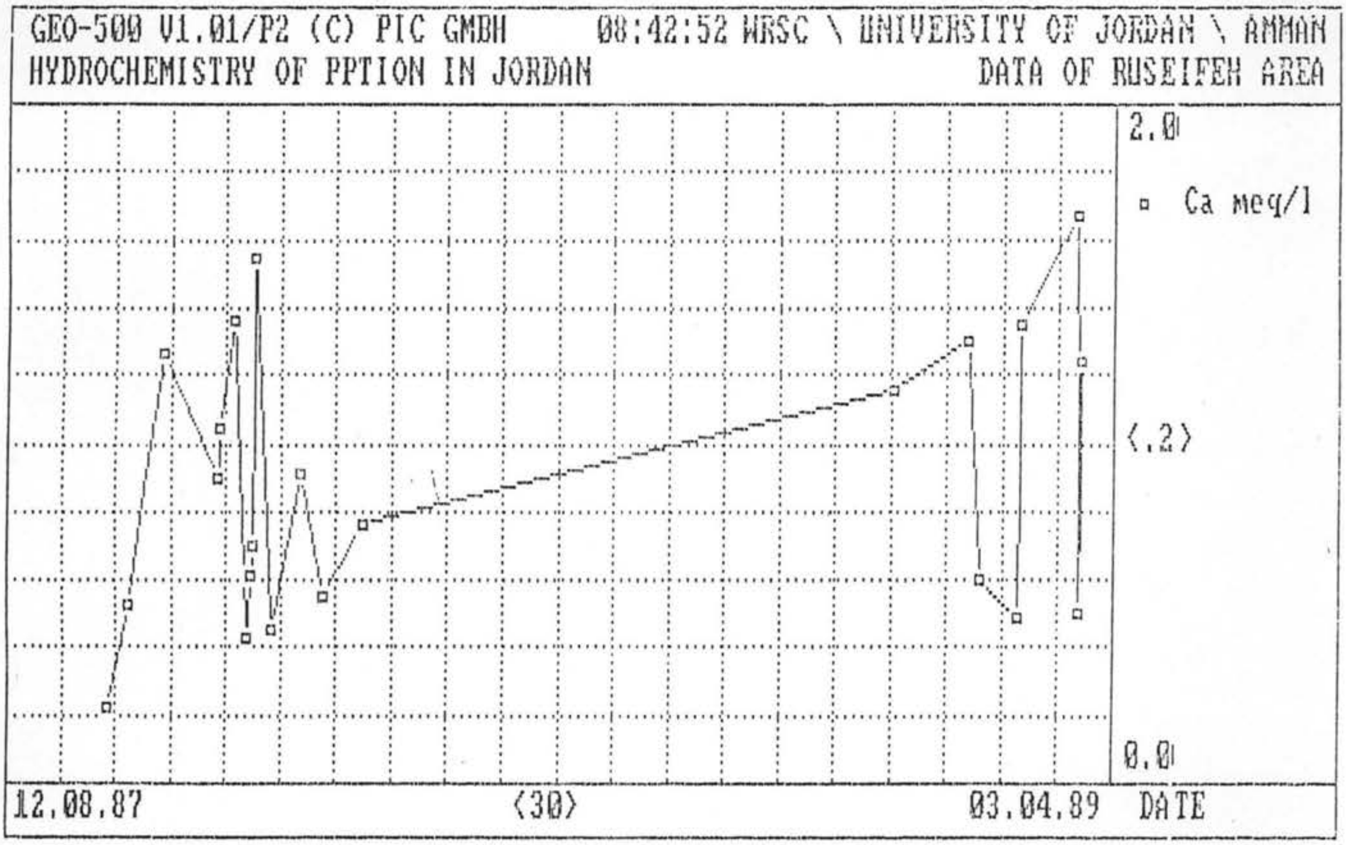
The calcium content ranged from 0.22 and 1.67 meq/l during the observation period with an average of 0.89 ± 0.42 meq/l, figure(20). The maximum concentration was recorded on the 14th of March,1989. On the other hand the magnesium content was found to range between 0.0 and 0.78 meq/l with an average value of 0.17 ± 0.19 meq/l, figure (21). The maximum concentration was recorded on the 18th of October 1987. Generally, the magnesium contents were lower than the calcium contents, this is attributed to the type of minerals contained in the atmospheres dust in the area; consisting of calcium containing minerals.

2.5- *Alkaline elements (Na^{+} and K^{+}).*

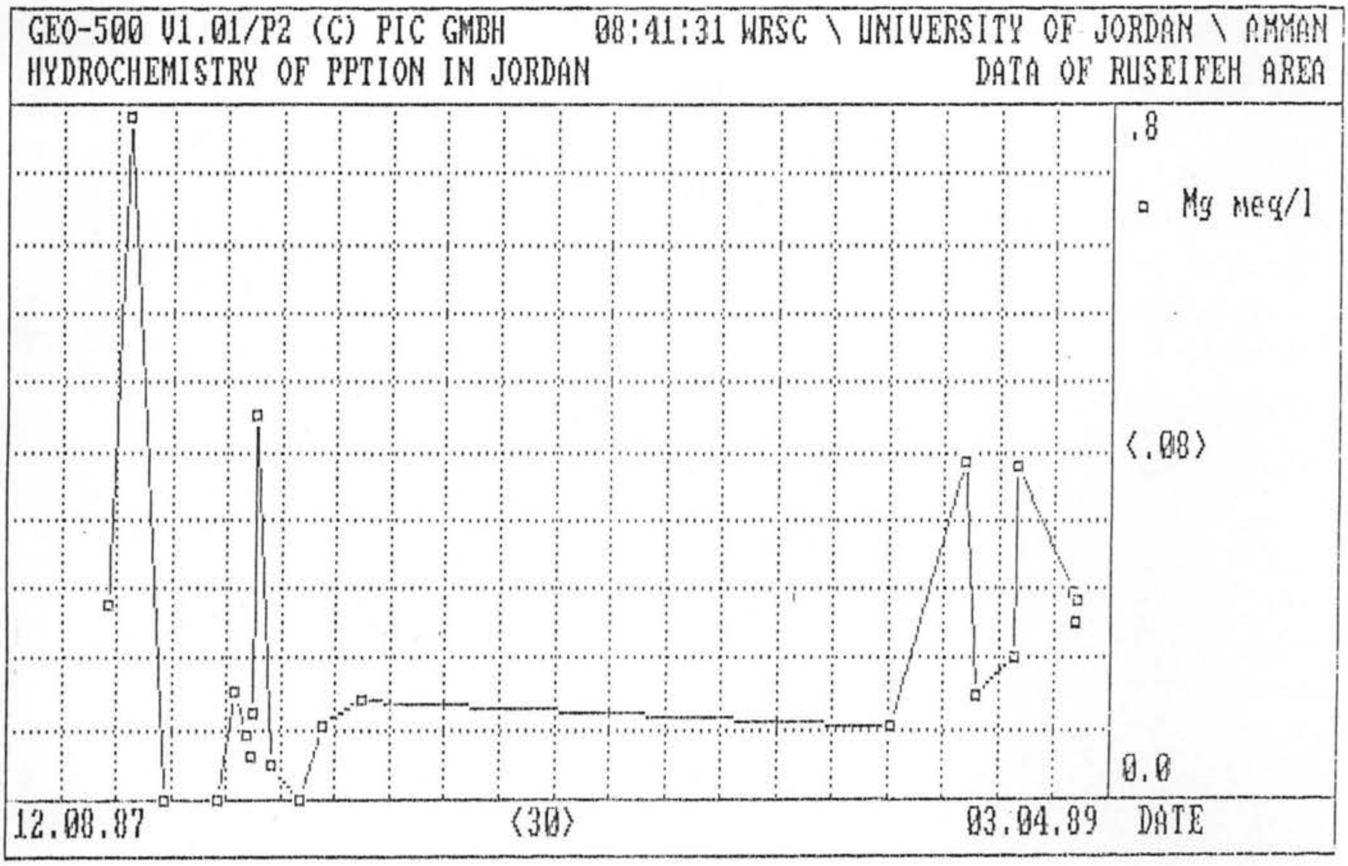
The sodium ion in ppt. samples showed that it is the second dominating ion in after calcium with an average percentage of 18.98%. The sodium content ranged from 0.015 to 0.881 meq/l with an average of 0.27 ± 0.23 meq/l, figure (22). The maximum Na-content was measured in ppt. samples collected on the 6th of November 1987. The potassium content ranged from 0.004 to 0.121 meq/l with an average of 0.030 ± 0.031 meq/l, figure (23). The maximum content was recorded in ppt. water sample on the 24th of December 1987.

2.6- *Chloride Cl^{-}*

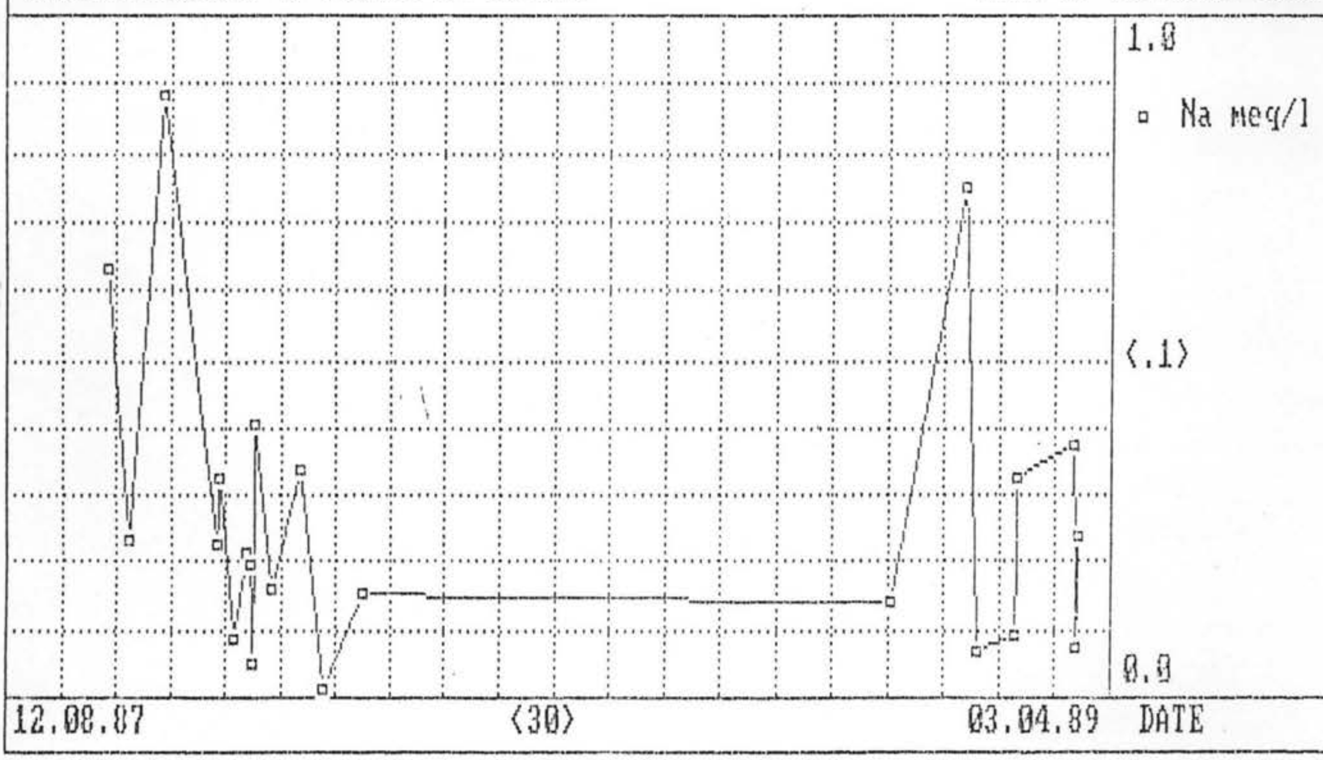
The chloride concentration in ppt. samples ranged from 0.147 to 0.477 meq/l with an average of 0.275 ± 0.095 meq/l, figure (24). Shows the fluctuations in the chloride content during the



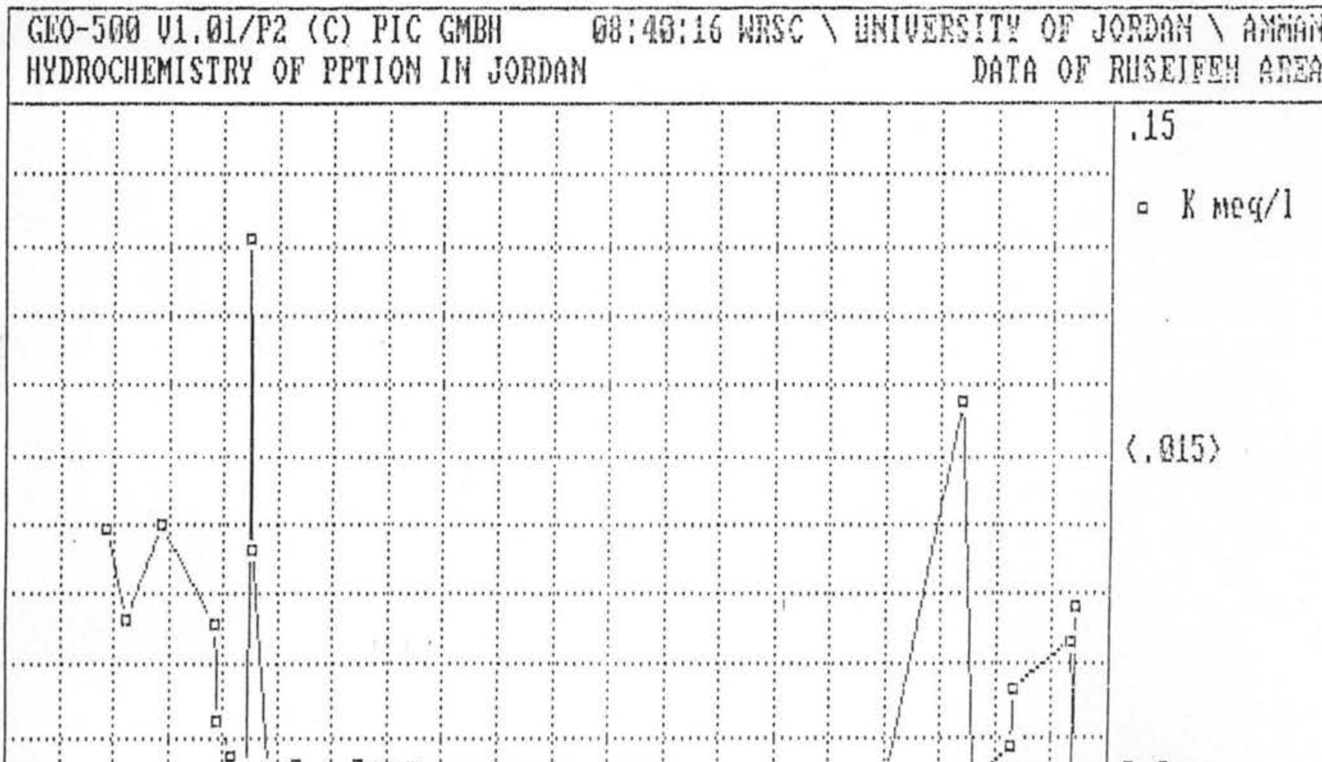
Figure(20): Fluctuations in Ca for Ruseifeh Station



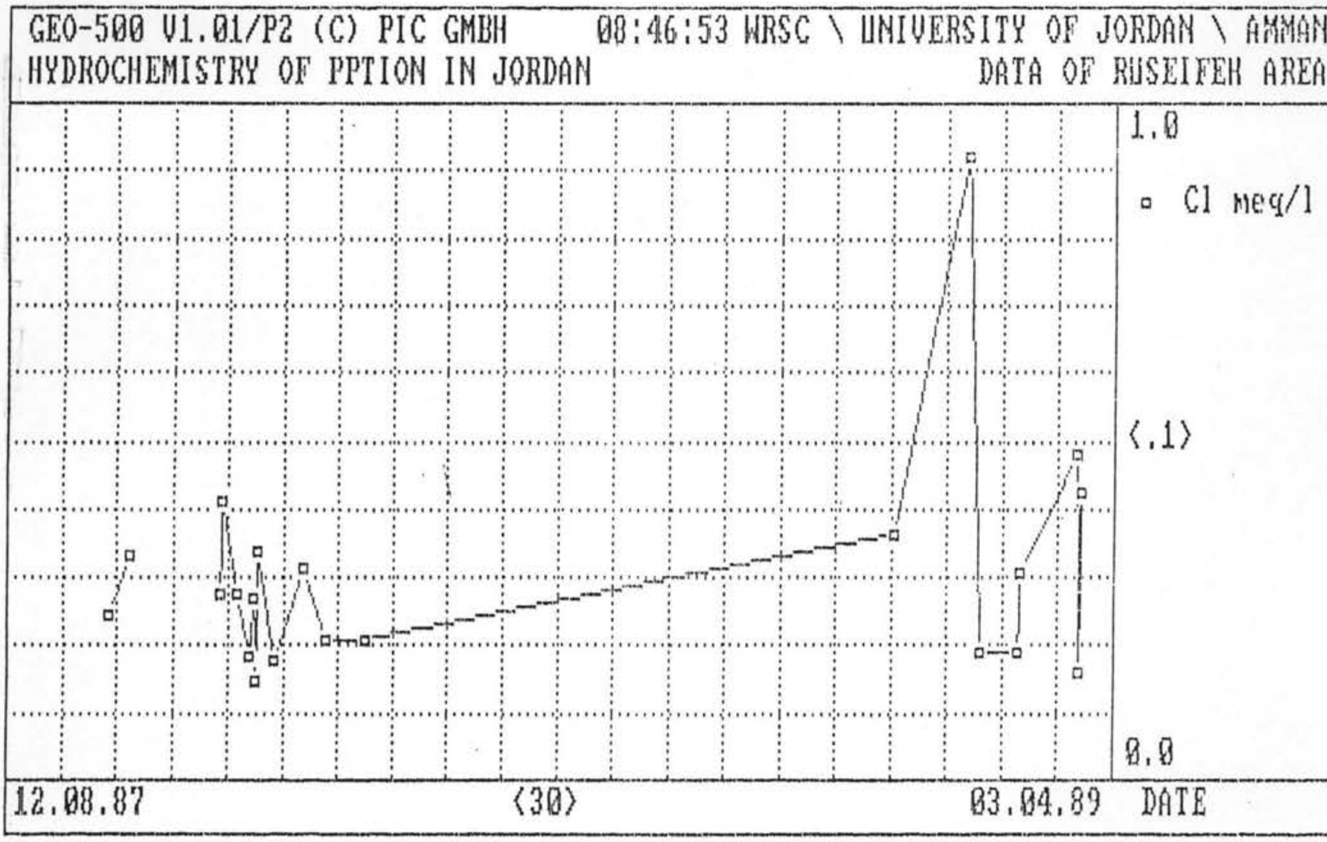
Figure(21): Fluctuations in Mg for Ruseifeh Station



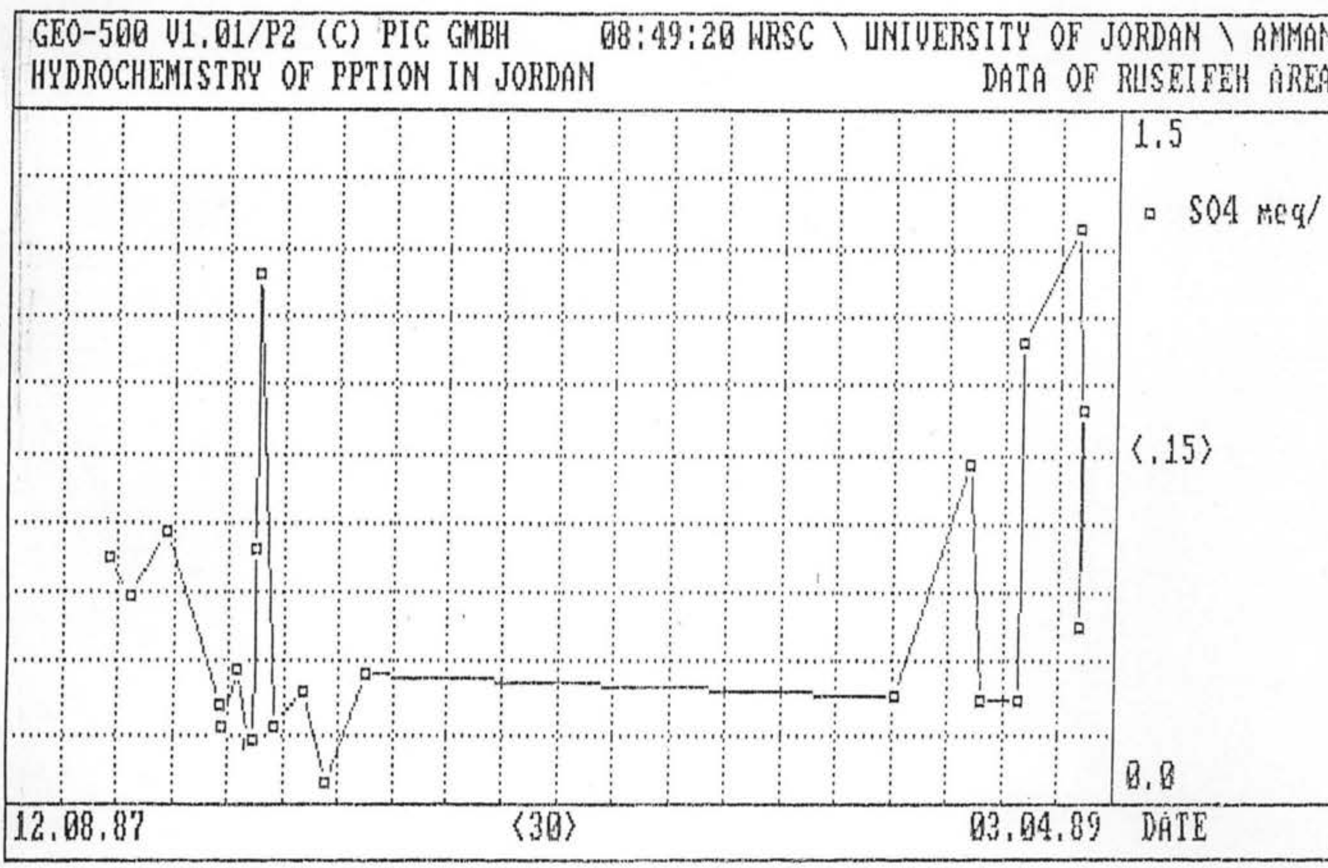
Figure(22): Fluctuations in Na for Ruseifeh Station



Figure(23): Fluctuations in K for Ruseifeh Station



Figure(24): Fluctuations in Cl for Ruseifeh Station



Figure(25): Fluctuations in SO_4 for Ruseifeh Station observation period. The maximum recorded concentration was measured in ppt. samples collected on the 14th of January 1989. Most of the samples contained chloride in the range between 0.28 ± 0.1.

2.7- Sulfate SO_4^{2-}

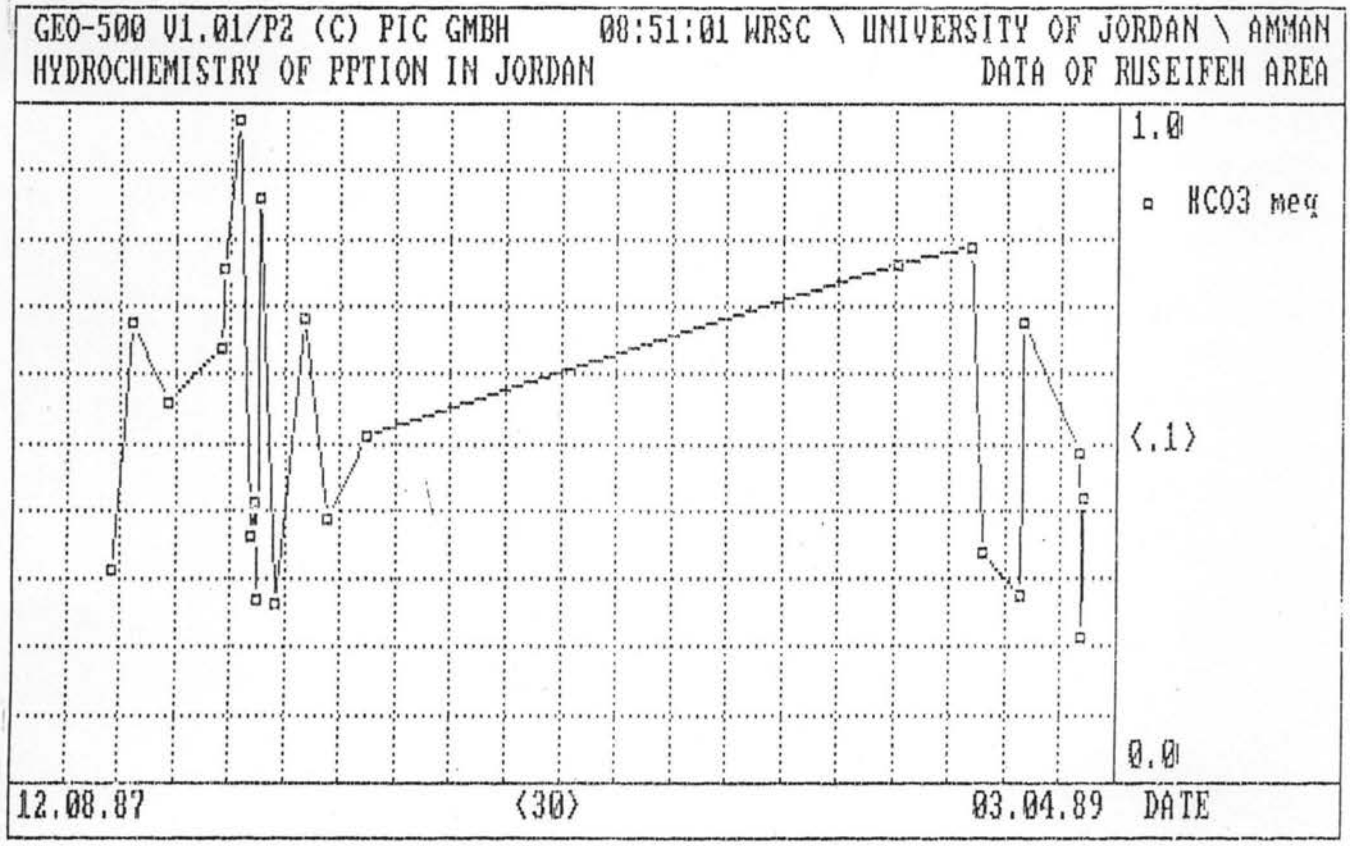
The sulfate content in rainwater collected from Ruseifeh, ranged from 0.043 to 1.239 meq/l, with an average value of 0.443 ± 0346 meq/l, figure (25). The maximum concentration measured on the 14th of March 1989, while the minimum was recorded on the 1st of February 1988. Dusty atmosphere prior to rainfall resulted in high contents of sulfates, calcium and bicarbonates.

2.8- Bicarbonate HCO_3^-

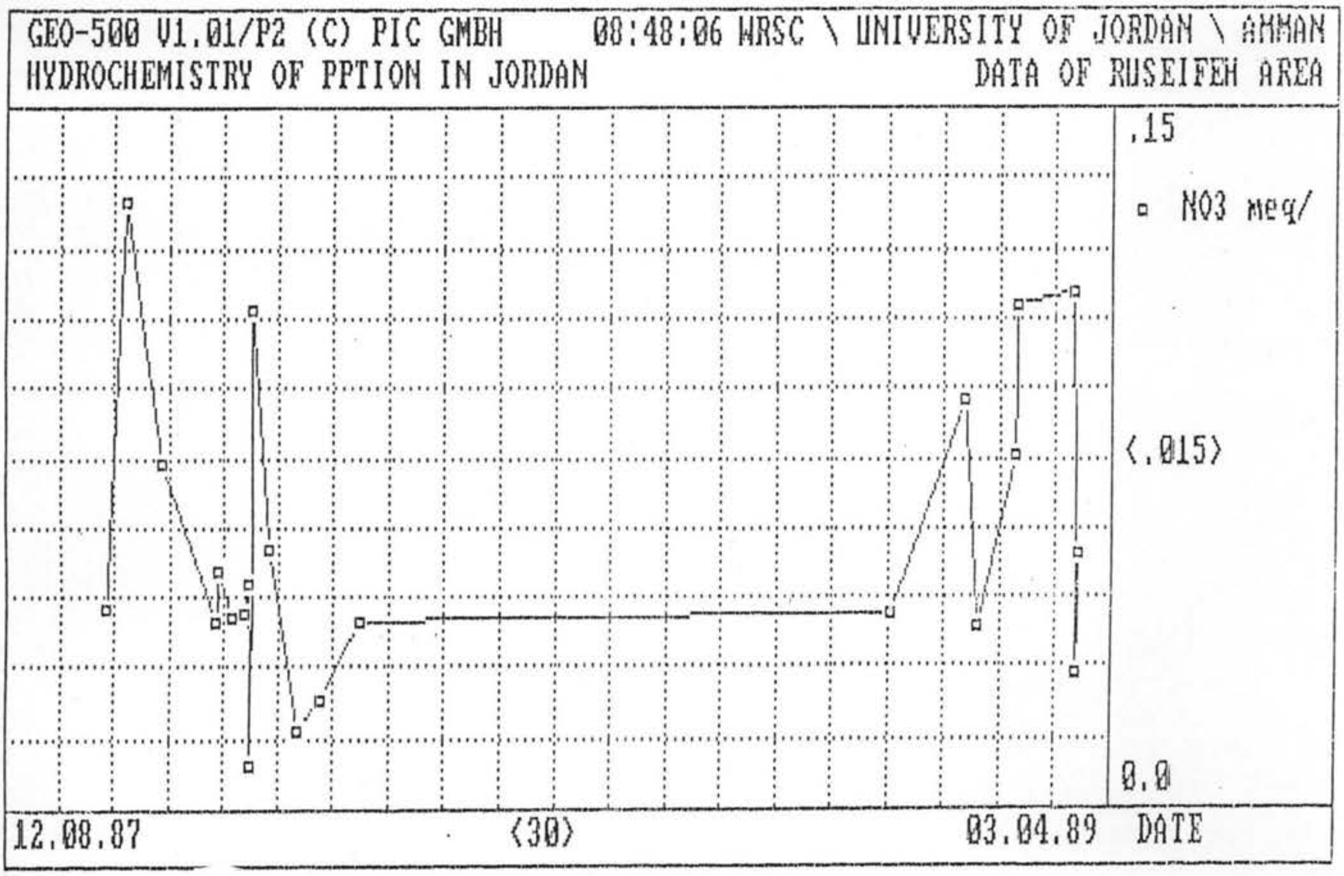
The bicarbonate fluctuations in ppt. is represented in figure (26). The bicarbonate content ranged from 0.214 to 0.976 meq/l with an average of 0.527 ± 0.221 meq/l. The maximum content was measured on the 15th of March, 1989. The bicarbonate contents are affected by the amount, duration, intensity, temperature and dust type in the atmosphere.

2.9- Nitrate NO_3^-.

The nitrate content ranged from 0.009 to 0.129 meq/l with an average of 0.057 ± 0.033 meq/l. figure (27). The maximum nitrate content was measured on the 18th of October 1987, while the minimum was recorded on the 24th of December 1987. Thunderstorms are the most responsible factor for the high content of nitrate in some rain water samples.



Figure(26): Fluctuations in HCO_3 for Ruseifeh Station



Figure(27): Fluctuations in NO_3 for Ruseifeh Station

2.10- Phosphate (PO_4^{3-})

The most obvious phenomenon in the rain water samples collected from Ruseifeh is their high content of phosphate which ranged from 0.177 to 4.198 mg/l with an average of 1.799 mg/l. This high concentration of phosphate is mainly attributed to the type of dust which mainly composed of apatite, calcite, quartz and kaolinite.

3- Khalidiya Station

Forty nine rain samples from khalidiya were collected during the rainy seasons and analysed for their chemical and physical characteristics in the period 1987/1988 to 1989/1990. The descriptive statistics of the measured parameters are shown in table (3).

Concentration and Fluctuations in the Analysed Parameters:

3.1- Amount of rainfall (mm):

The highest recorded amount of rainfall in a single rainstorm was 39.1 mm. Recorded on the 1st of February 1988 where successive depressions affected the country. Figure (28) shows the fluctuations in the amount of ppt. during the observation period.

3.2- pH-value.

The measured pH-value of ppt. water samples ranged from 6.28 to 8.74, with an average of 7.60 ± 0.51 . Figure (29) shows the fluctuations in the measured pH of rain water. The highest pH values at this station were obtained during December of the rainy season 1987/1988 and the minimum pH-value was measured on the 18th of November 1988.

3.3- Electrical conductivity EC µs/cm.

The EC of ppt. water samples ranged from 40 to 570 µs/cm, figure(30). The average EC was found to be 165.1 ± 109.2 µs/cm. The minimum EC was measured on the 4th of January 1988; where successive depressions of polar origin affected Jordan. Whereas the maximum EC was measured on the 15th of November 1989.

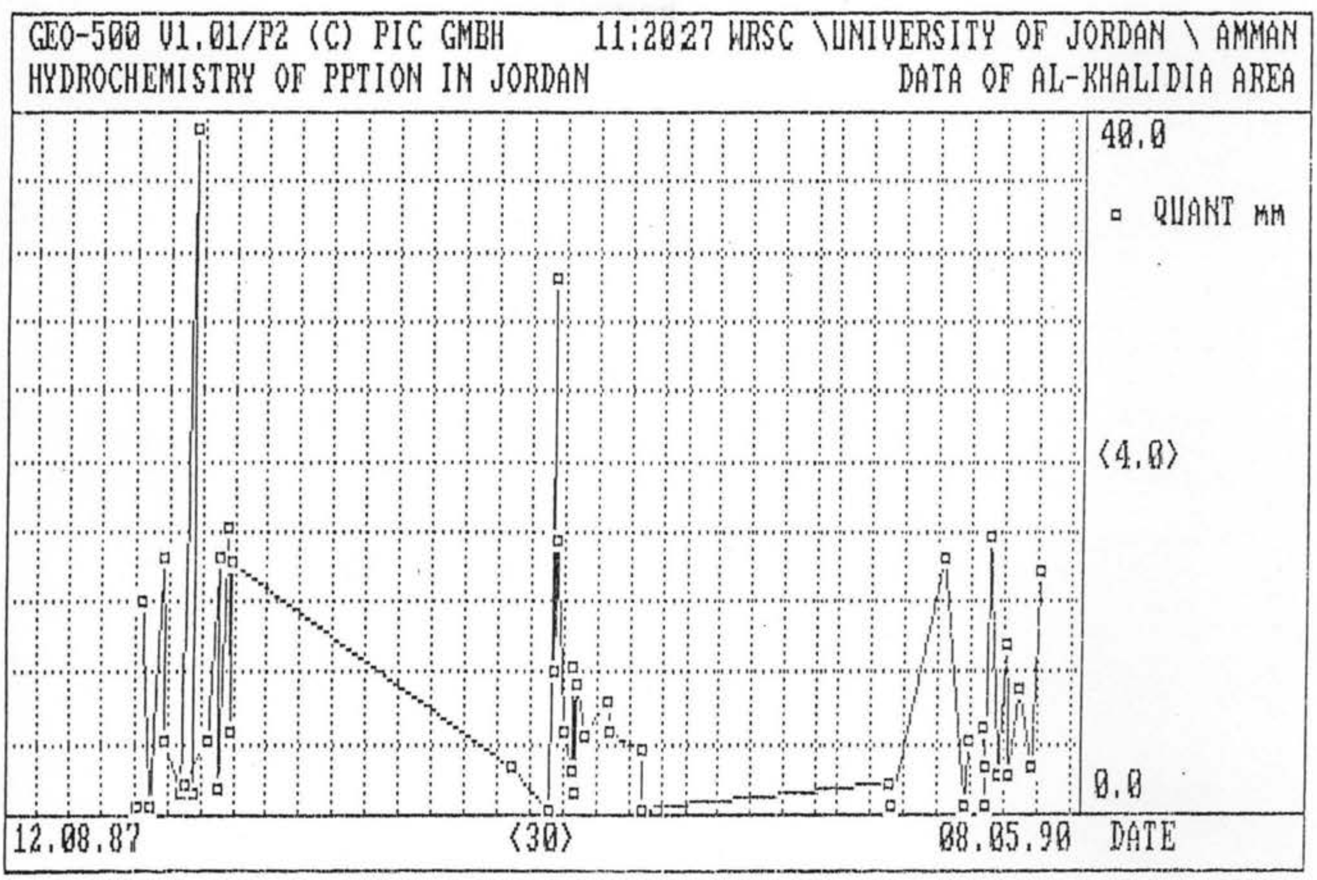
STASY V7.0?/12 (C) PIC GMBH — WRSC UNIV.JORDAN 10.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN — DATEI A:NEW-KHLD VOM 15.07.15

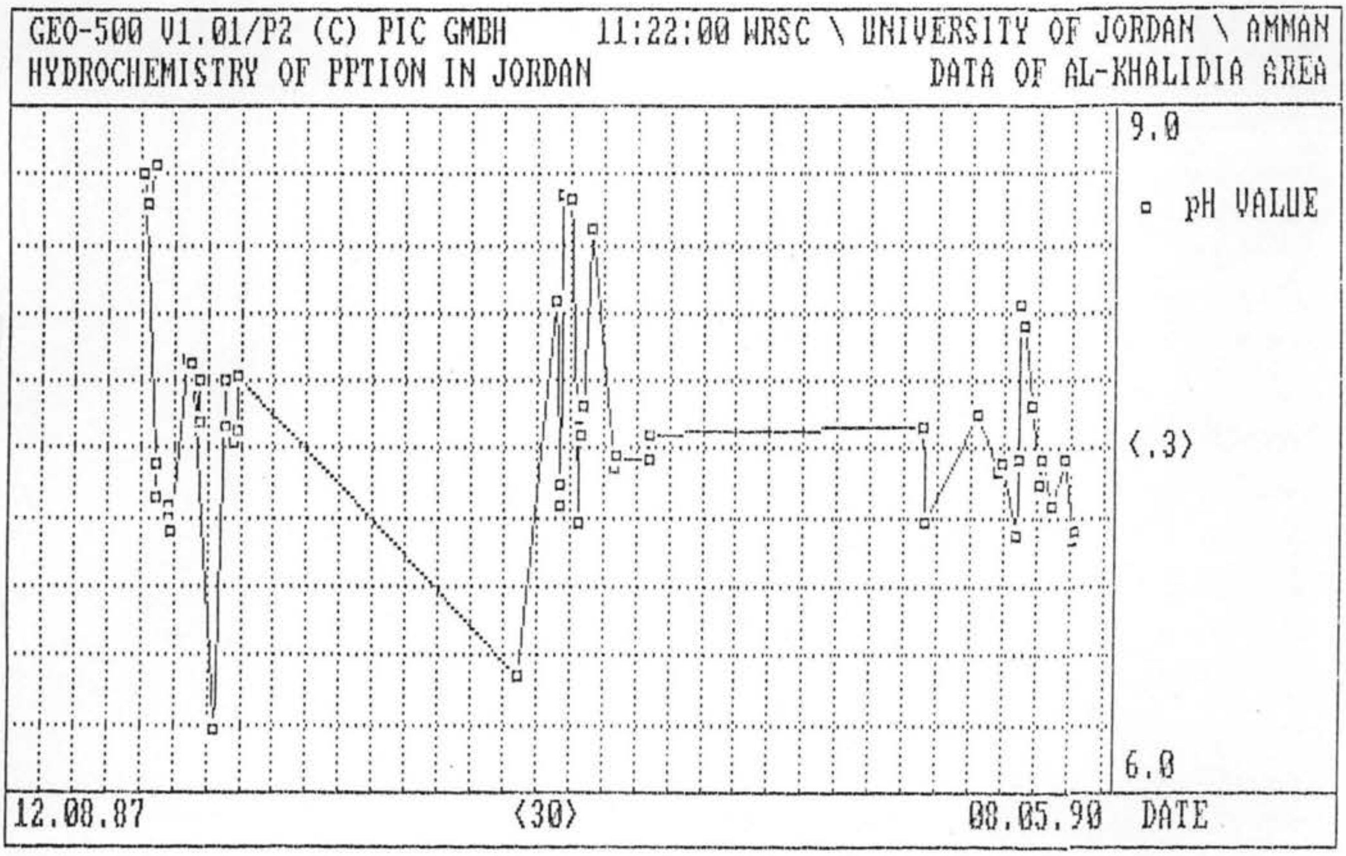
2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32122.0	32964.0	32518.266	316.003
QUANT mm	0.2	39.1	6.835	7.888
TEMP °C	0.0	16.2	13.700	5.069
pH VALUE	6.28	8.74	7.6020	0.5106
EC µS/cm	40.0	570.0	165.092	109.182
Na meq/l	0.011	1.054	0.23290	0.20548
K meq/l	0.002	0.926	0.08035	0.14005
Mg meq/l	0.000	1.065	0.17478	0.20585
Ca meq/l	0.270	3.329	1.16464	0.77502
Cl meq/l	0.074	1.594	0.33432	0.26072
NO3 meq/	0.018	1.619	0.11364	0.24001
SO4 meq/	0.052	1.645	0.37418	0.35817
HCO3 meq	0.116	4.810	0.82879	0.80323
TC meq/l	0.400	5.700	1.65267	1.09174
TA meq/l	0.400	5.700	1.65092	1.09182
I mg/l	0.000	0.025	0.00993	0.00838
Br mg/l	0.000	1.550	0.22617	0.33818
F mg/l	0.001	0.087	0.03770	0.02773
PO4 mg/l	0.000	3.810	0.71033	1.05948
TOC mg/l				
Li mg/l	0.000	0.064	0.02134	0.01825
TURBIDY	0.0	30.0	12.912	11.127
COLOR	1.0	67.5	20.979	21.559
TDS 104°	0.020	0.180	0.09813	0.06221
TDS 180°	0.010	0.190	0.06824	0.05318
Ag mg/l	0.00000	0.08500	3.468E-03	1.571D-02
TIME hr	8.00	17.00	12.5000	6.3640
Fe mg/l	0.00000	21.76000	1.695E+00	4.977D+00
Cu mg/l	0.00000	0.02300	3.963E-03	6.381D-03
Mn mg/l	0.00000	0.27700	2.911E-02	6.377D-02
Zn mg/l	0.00000	0.63000	7.387E-02	1.509D-01
Pb mg/l	0.00000	0.00200	3.742E-04	6.370D-04
Cr mg/l	0.00000	0.02200	1.528E-03	5.053D-03
Ni mg/l	0.00000	0.05830	8.558E-03	1.818D-02
Sr mg/l	0.00268	0.08700	4.838E-02	3.298D-02

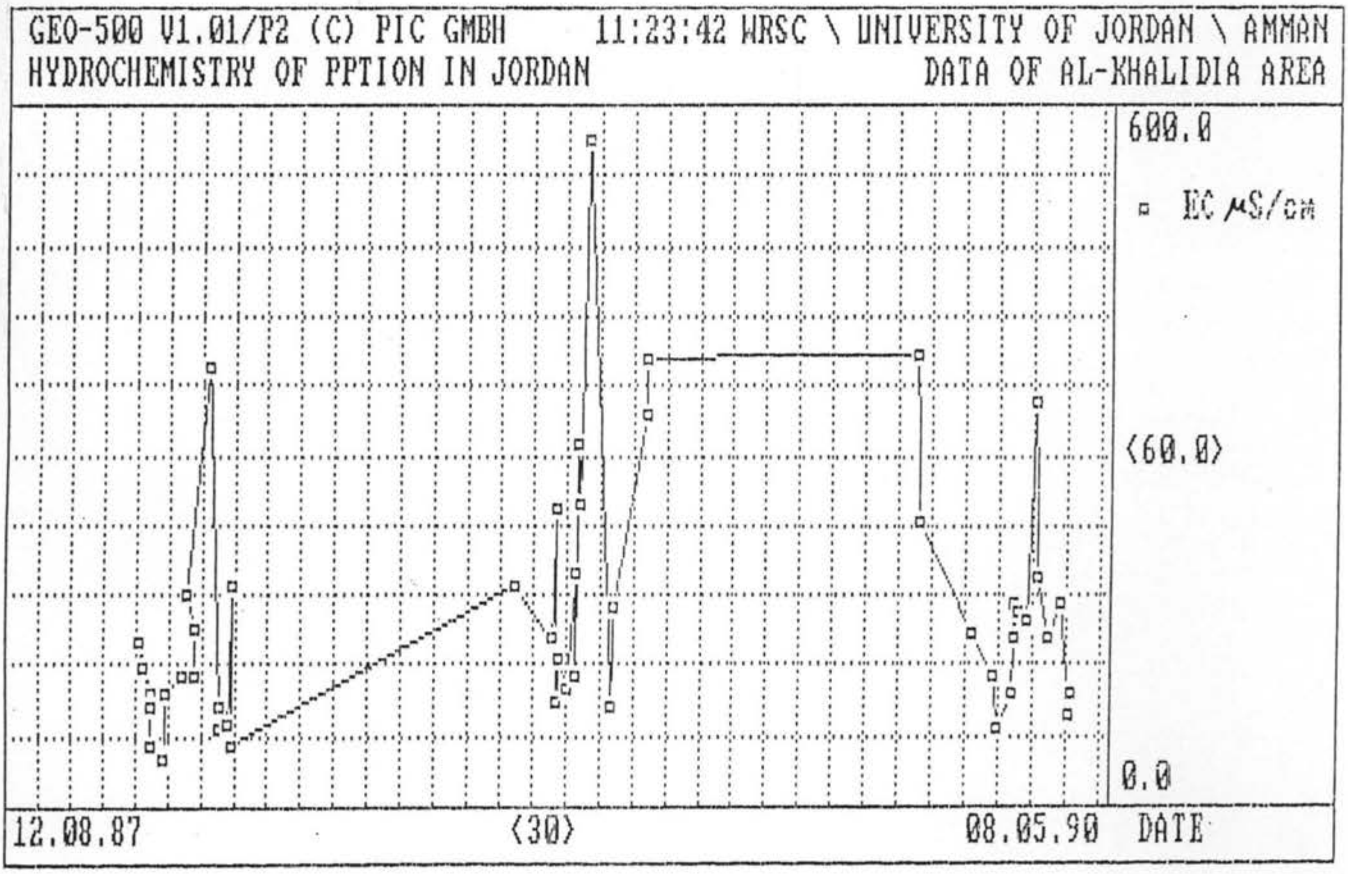
Table(3): Descriptive Statistics for Khalidiya Station



Figure(28): Fluctuations in ppt. Amounts for Khalidiya Station



Figure(29): Fluctuations in pH for Khalidiya Station



Figure(30): Fluctuations in EC for Khalidiya Station

3.4- *Earth Alkaline Elements (Ca^{2+} & Mg^{2+})*

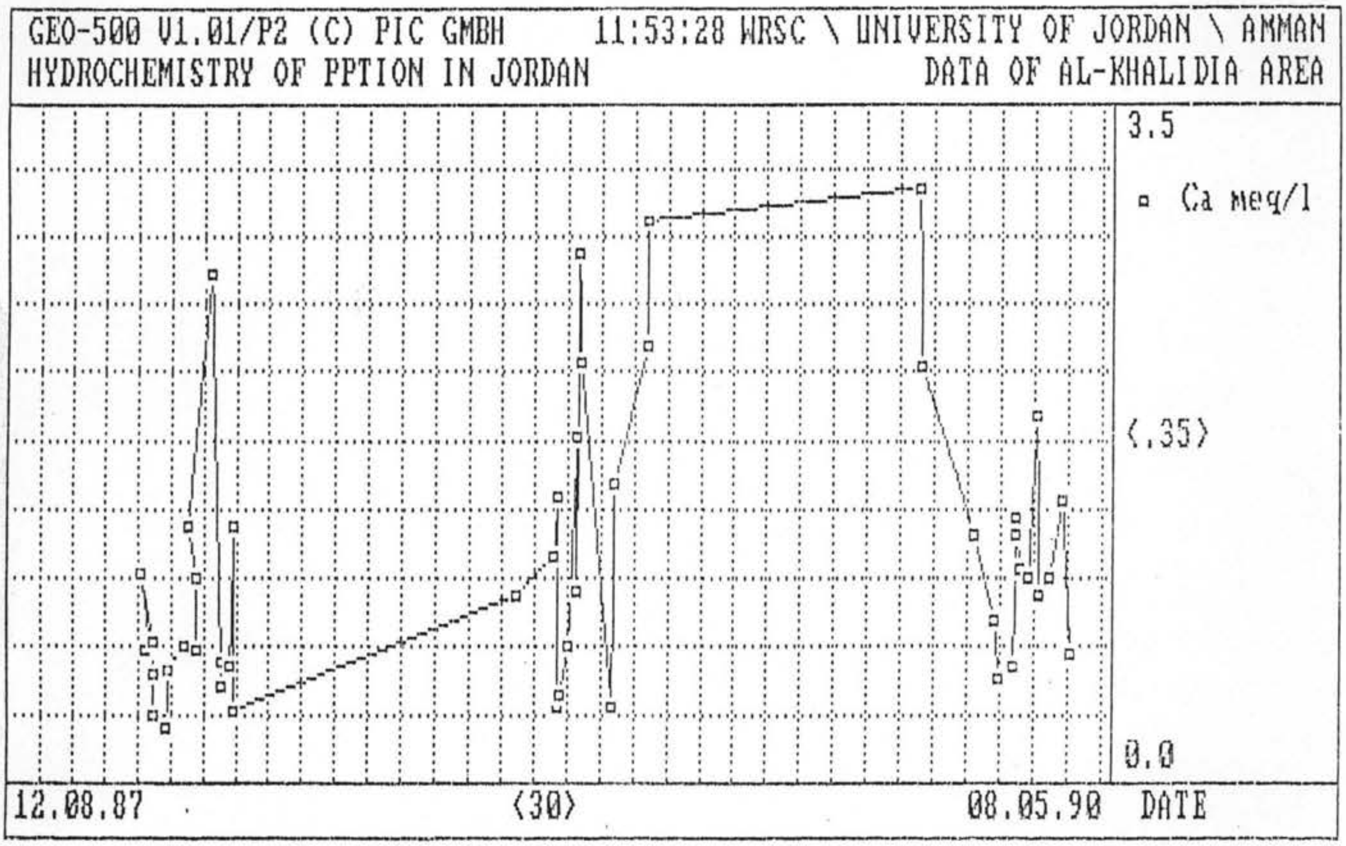
The earth alkaline elements represent the major cations in the rain samples of this station, with an average of 1.16 ± 0.78 meq/l. On the other hand the magnesium content ranged from 0.00 (magnesium free water sample) to 1.07 meq/l, with an average of 0.17 ± 0.21 meq/l, figures (31 and 32). Show the fluctuations of the calcium and magnesium contents respectively in rain water samples collected during the study period.

3.5- *Alkaline Elements (Na^+ and K^+)*

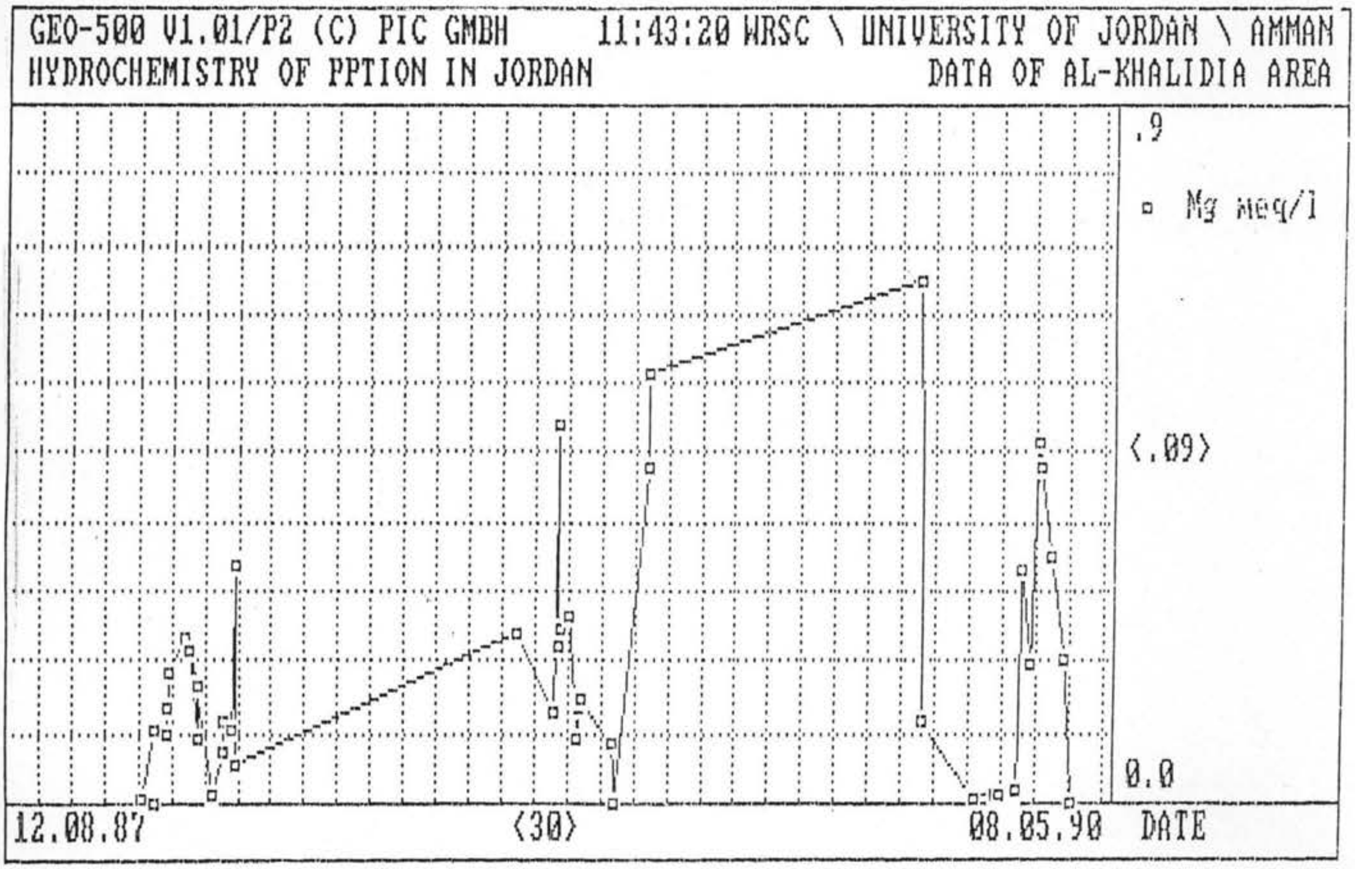
The sodium ion in ppt. samples showed that it is the second ion in dominance after calcium, where the average sodium percentage was 14.96 ± 9.92 % . The sodium content ranged from 0.011 to 1.054 meq/l, with an average of 0.233 ± 0.205 meq/l. Figure (33), shows the fluctuations of the sodium content during the study period. The maximum measured sodium was on the 1st of March 1990, when eastern winds prevailed in the area (khamasien winds). The potassium content ranged from 0.002 to 0.926 meq/l with an average of 0.080 ± 0.140 meq/l, figure (34). The maximum potassium content was measured on the 1st of March 1990.

3.6- *Chloride (Cl^-)*

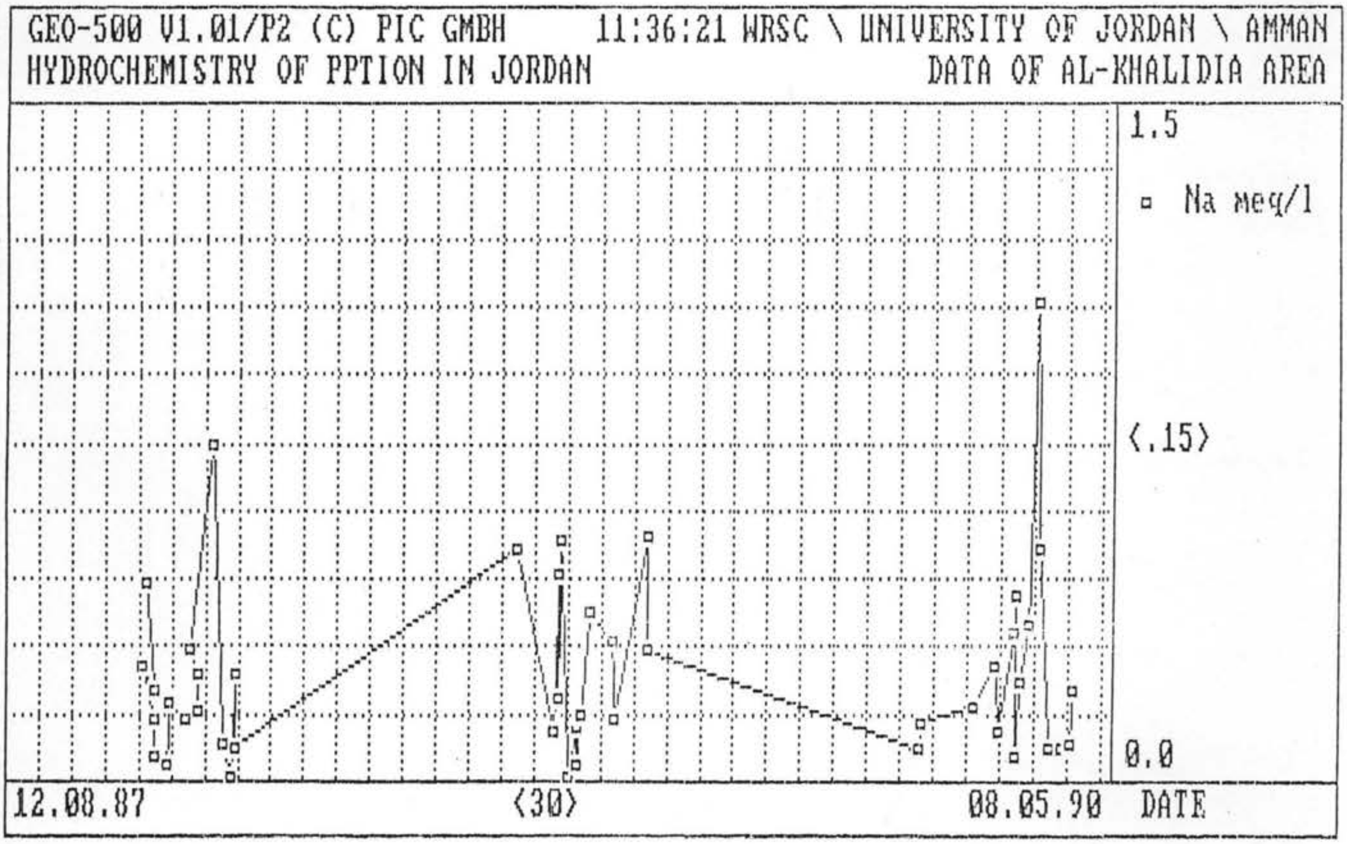
The chloride content ranged from 0.074 to 1.594 meq/l, with an average of 0.334 ± 0.261 meq/l. Figure (35), shows the fluctuations in the chloride content in ppt. samples. The maximum chloride concentration was measured on the 1st of March 1990, when the Khamasieni winds affected Jordan.



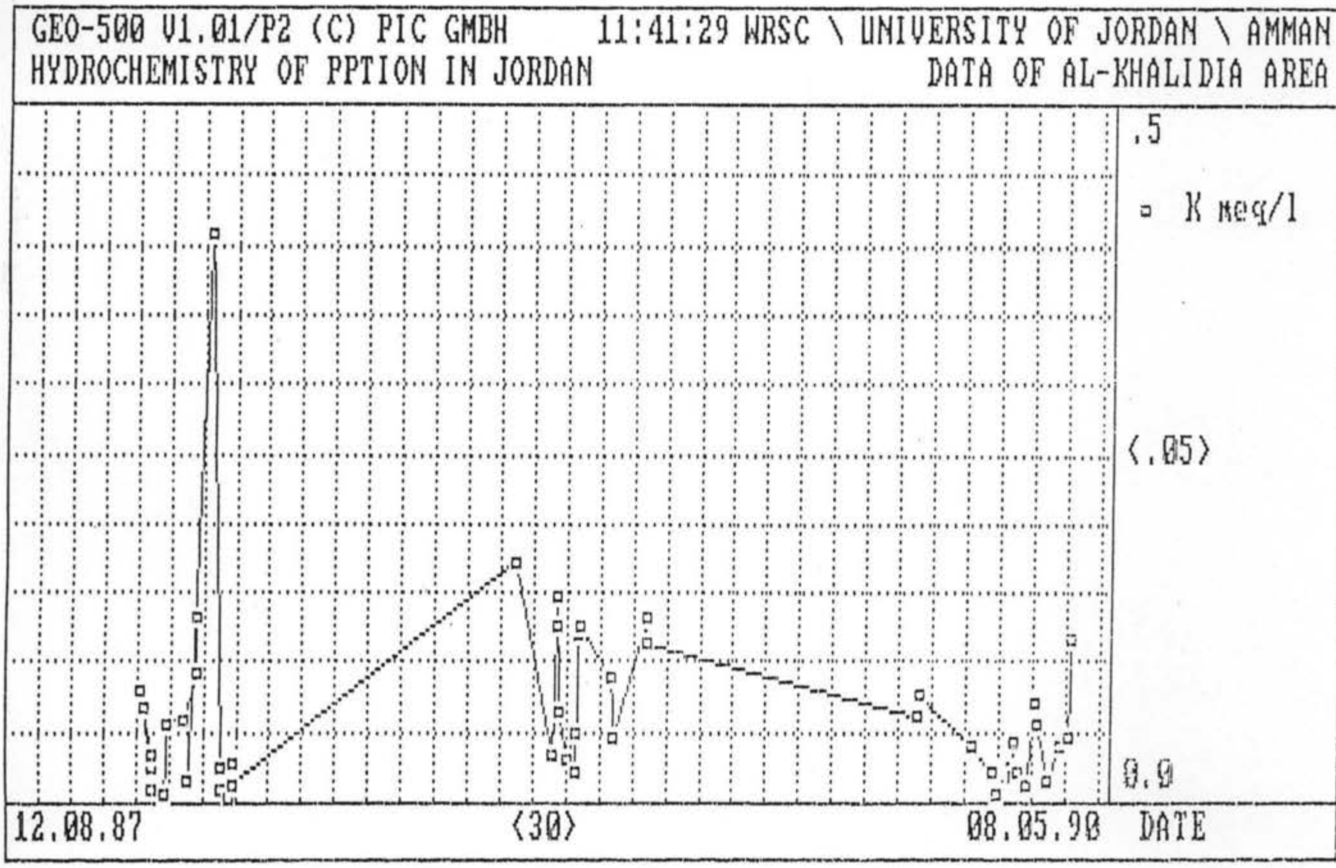
Figure(31): Fluctuations in Ca for Khalidiya Station



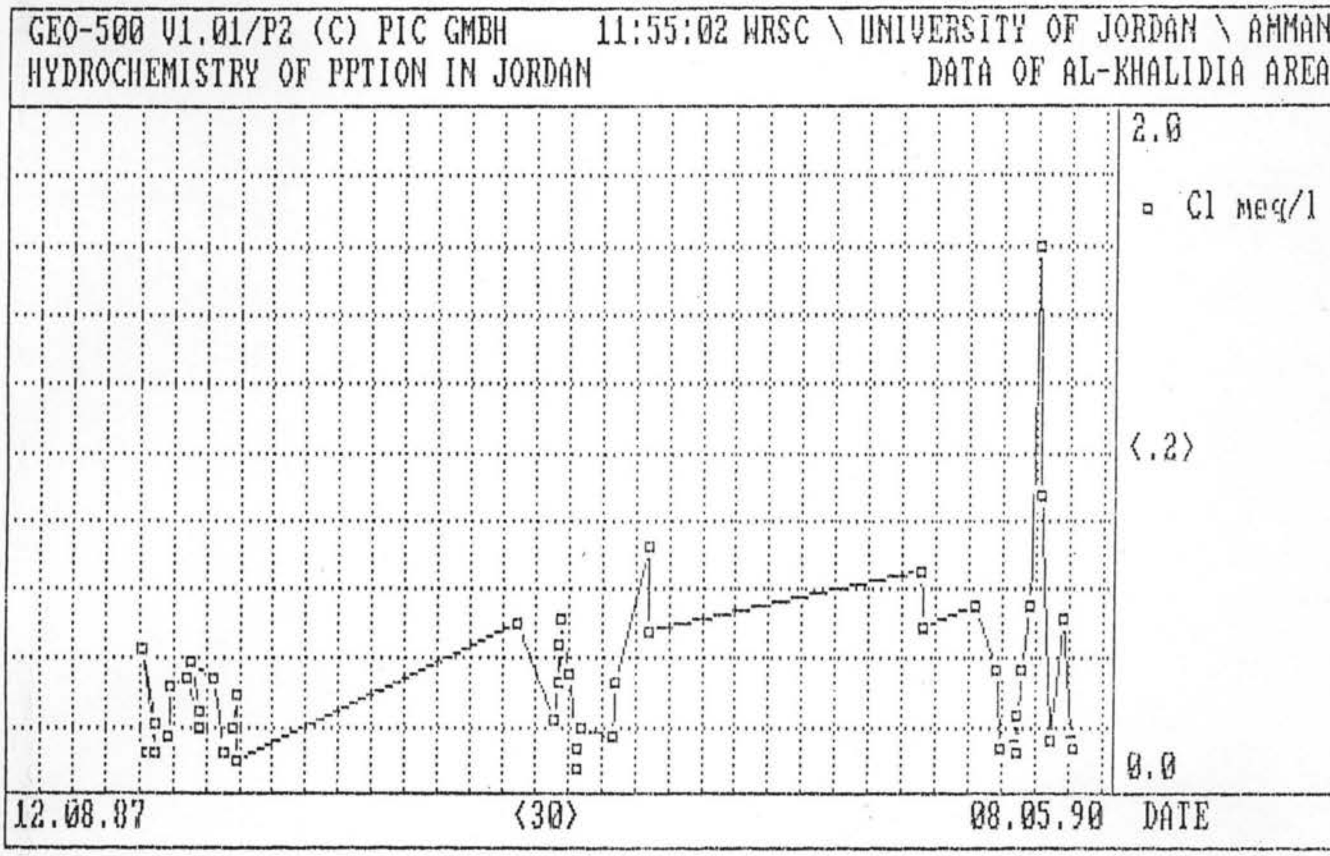
Figure(32): Fluctuations in Mg for Khalidiya Station



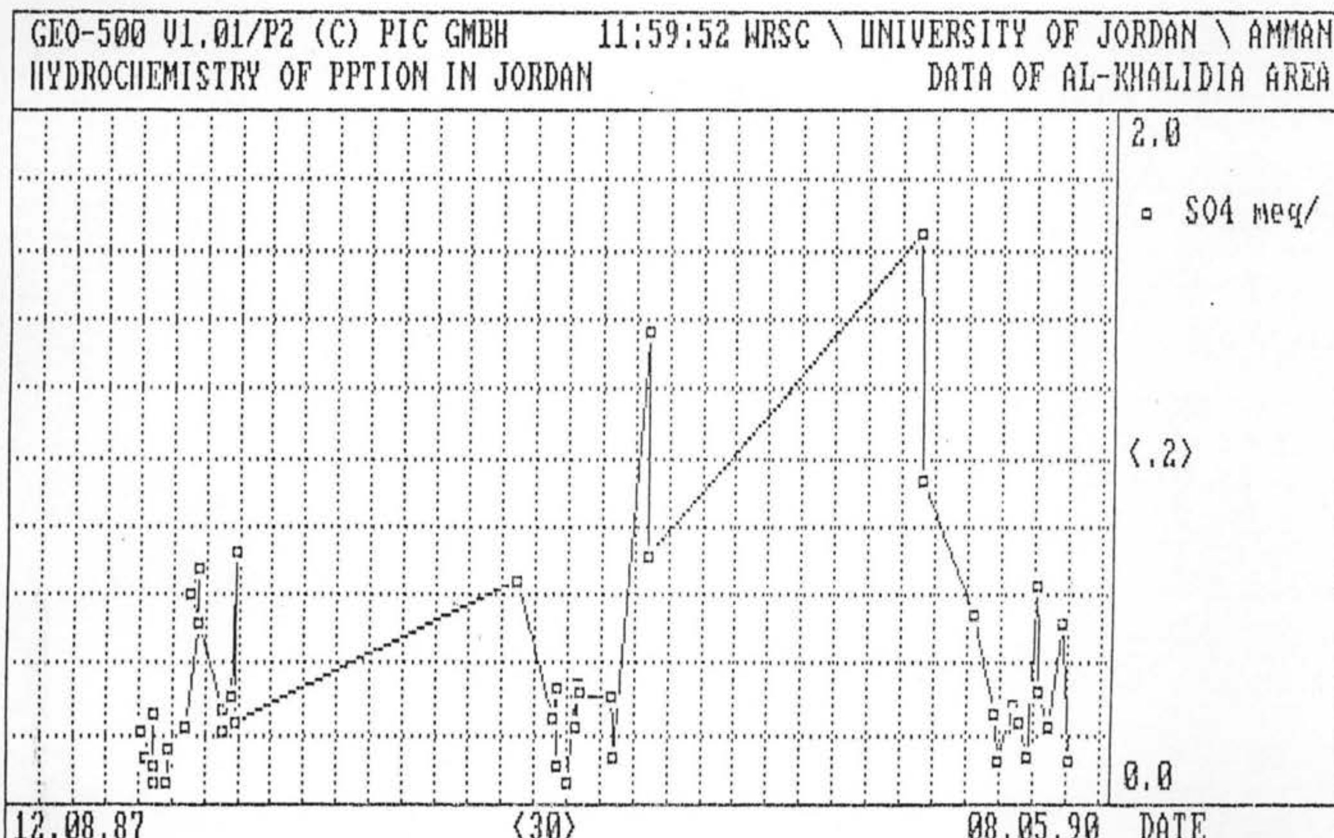
Figure(33): Fluctuations in Na for Khalidiya Station



Figure(34): Fluctuations in K for Khalidiya Station



Figure(35): Fluctuations in Cl for Khalidiya Station



Figure(36): Fluctuations in SO_4 for Khalidiya Station

3.7- Sulfate (SO_4^{2-})

The sulfate content in rain water collected from khalidiya ranged from 0.052 to 1.645 meq/l, figure (36). The average sulfate content was found to be 0.374 ± 0.358 meq/l. The maximum sulfate concentration was measured on the 15th of November 1989.

3.8- Nitrate (NO_3^-)

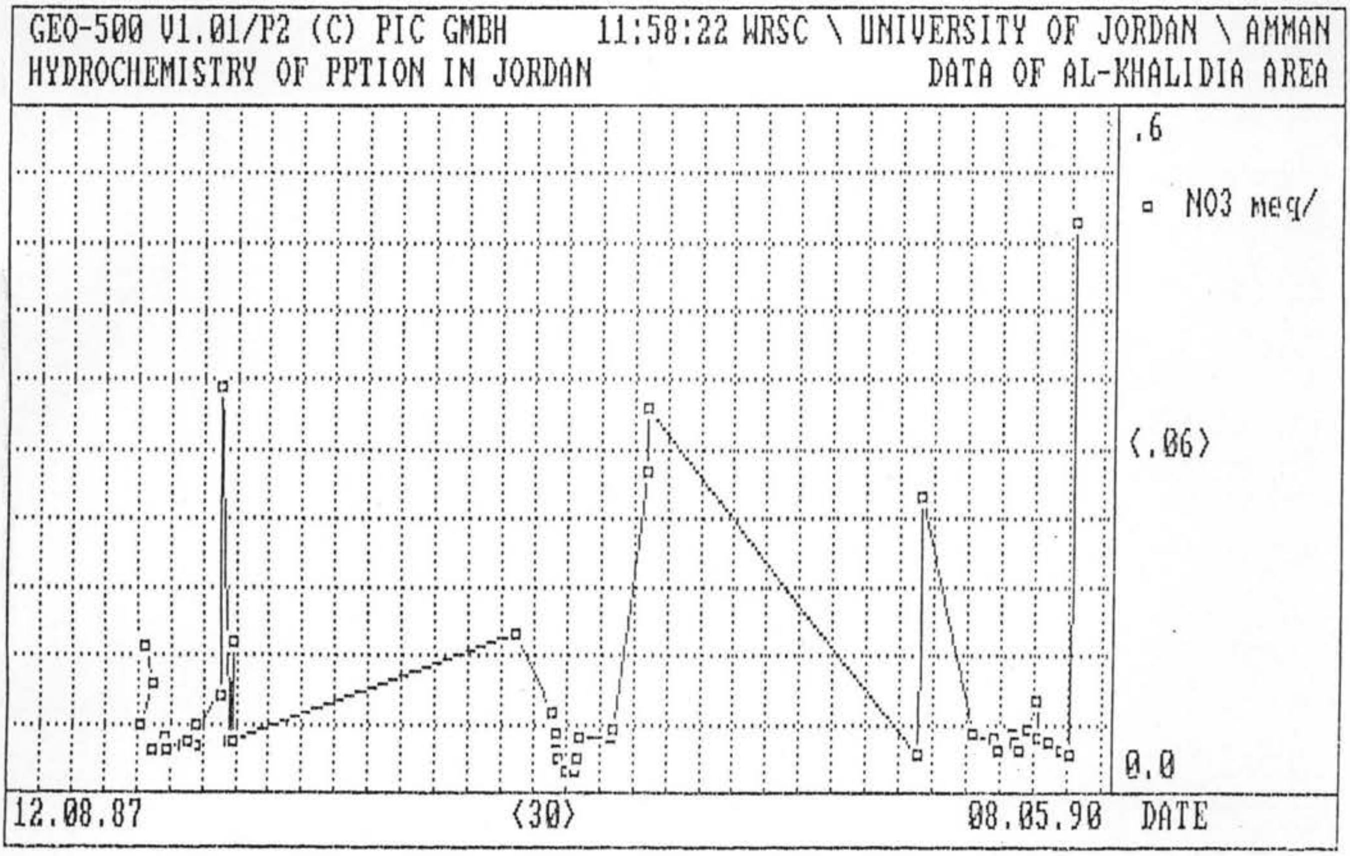
Figure (37), shows the fluctuation in the nitrate content of rain water samples during the study period. The nitrate content ranged from 0.018 to 0.5 meq/l, with an average of about 0.114 ± 0.4 meq/l. Generally, maximum nitrate contents in Jordan are mainly attributed to thunderstorms, but in this area it was associated with dust storms originating from the surrounding cultivated area, where other ions such as potassium and phosphate showed higher concentrations than usual.

3.9- Bicarbonate HCO_3^-

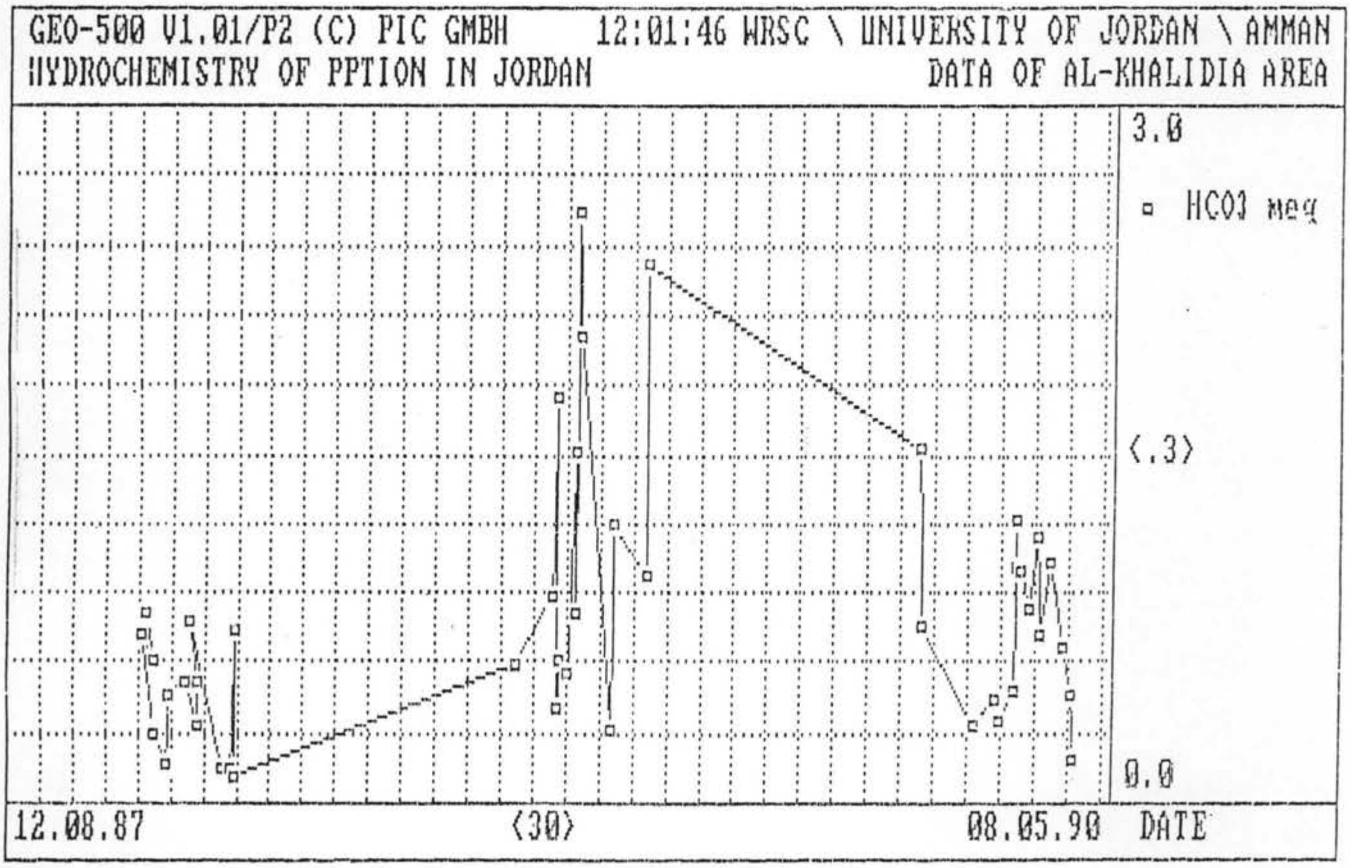
The fluctuations in the bicarbonate contents are shown in figure (38). The bicarbonate concentration was found to range from 0.116 to 4.810 meq/l with an average of about 0.829 ± 0.803 meq/l. The maximum measured value was registered on the 13th of January 1989, and the minimum on the 7th of March 1988.

3.10- Phosphate (PO_4^{3-})

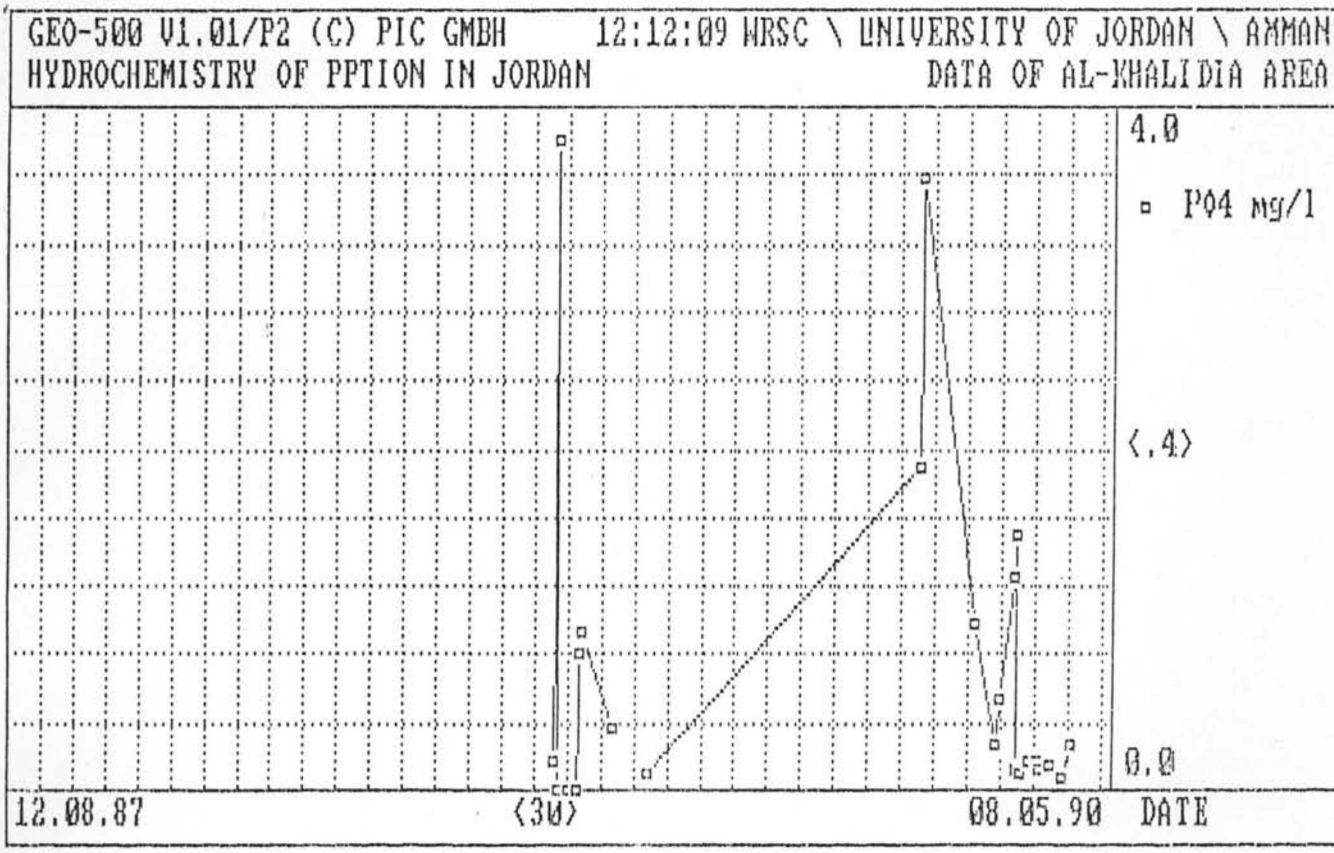
The phosphate concentration in rain water samples collected during the study period ranged from 0.000 (phosphate free rain water) to 3.810 mg/l with an average of about 0.710 ± 1.059 mg/l. The phosphate fluctuations in ppt. samples is represented in Figure (39).



Figure(37): Fluctuations in NO_3 for Khalidiya Station



Figure(38): Fluctuations in HCO_3 for Khalidiya Station



Figure(39): Fluctuations in PO_4 for Khalidiya Station

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HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-AZRQ VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32129.0	32490.0	32299.188	144.623
QUANT mm	0.1	11.0	2.609	3.028
TEMP °C.	9.0	32.6	16.908	6.479
pH VALUE	6.34	7.67	7.1392	0.3422
EC µS/cm	19.0	642.0	272.740	173.381
Na meq/l	0.009	2.381	0.60578	0.60539
K meq/l	0.001	0.149	0.05798	0.04675
Mg meq/l	0.000	1.447	0.32184	0.41031
Ca meq/l	0.175	4.573	1.74182	1.16373
Cl meq/l	0.061	1.953	0.66841	0.55458
NO3 meq/	0.025	0.560	0.11351	0.11384
SO4 meq/	0.000	2.617	0.70191	0.68831
HCO3 meq	0.101	2.733	1.24357	0.86042
TC meq/l	0.190	6.420	2.72740	1.73381
TA meq/l	0.190	6.420	2.72740	1.73381
I mg/l	0.000	0.445	0.07433	0.13930
Br mg/l	0.000	0.830	0.17038	0.23331
F mg/l	0.008	0.252	0.09714	0.07702
PO4 mg/l	0.000	1.141	0.50385	0.42830
TOC mg/l				
Li mg/l	0.000	0.120	0.04050	0.03938
TURBIDY	5.0	100.0	42.091	33.599
COLOR	1.0	80.0	23.214	25.329
TDS 104°	0.180	0.440	0.29600	0.13221
TDS 180°	0.160	0.430	0.27200	0.13989
Ag mg/l	0.00000	0.00270	1.217E-03	1.161D-03
TIME hr				
Fe mg/l	0.02500	1.93000	6.344E-01	7.666D-01
Cu mg/l	0.00000	0.01060	4.406E-03	4.602D-03
Mn mg/l	0.00000	0.05670	1.940E-02	2.260D-02
Zn mg/l	0.00000	0.10500	4.808E-02	4.650D-02
Pb mg/l	0.00000	0.00486	2.320E-03	1.926D-03
Cr mg/l	0.00000	0.00347	8.140E-04	1.507D-03
Ni mg/l	0.00000	0.04980	1.358E-02	2.171D-02
Sr mg/l				

Table(4): Descriptive Statistics for Azraq Station

4- Azraq Station

Twenty five rain samples were collected from Azraq and analysed during the study period. The average yearly amount of rainfall in the Azraq area in a wet year reaches about 100 mm while in dry years it is less than 25 mm/yr. Rainfall occurred in this area only in few scattered days during rainy seasons. The descriptive statistics of the analysed physical and chemical parameters are represented in table (4).

Concentrations and Fluctuations in the Physical and Chemical Parameters:

4.1- Amount of Rainfall in (mm) :

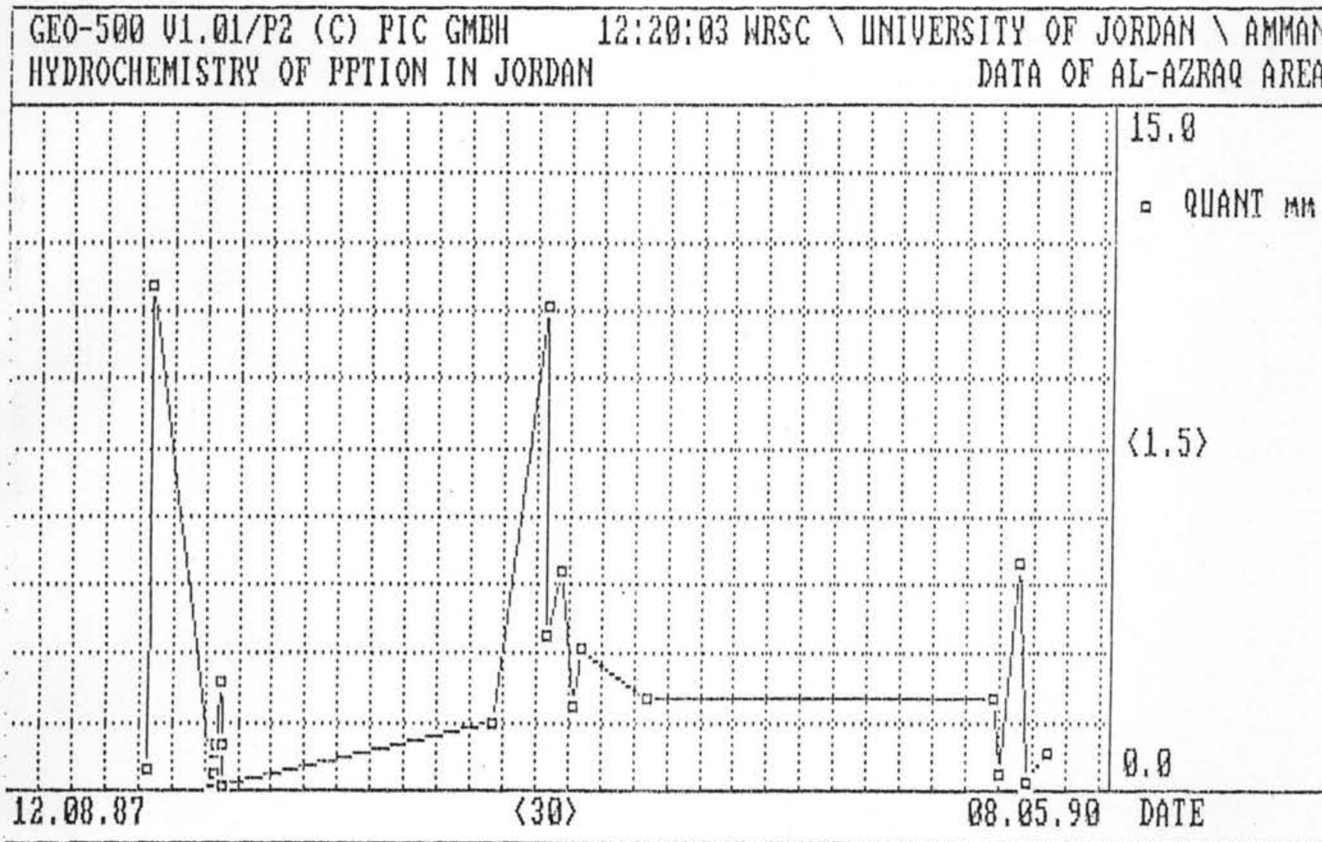
The measured amount of rainfall collected from Azraq ranged from 0.1 to 11 mm. The fluctuations in the amount of ppt. in Azraq area is represented in figure (40). The maximum rainfall amount of which a sample was collected occurred on the 20th of December 1987.

4.2- pH-value

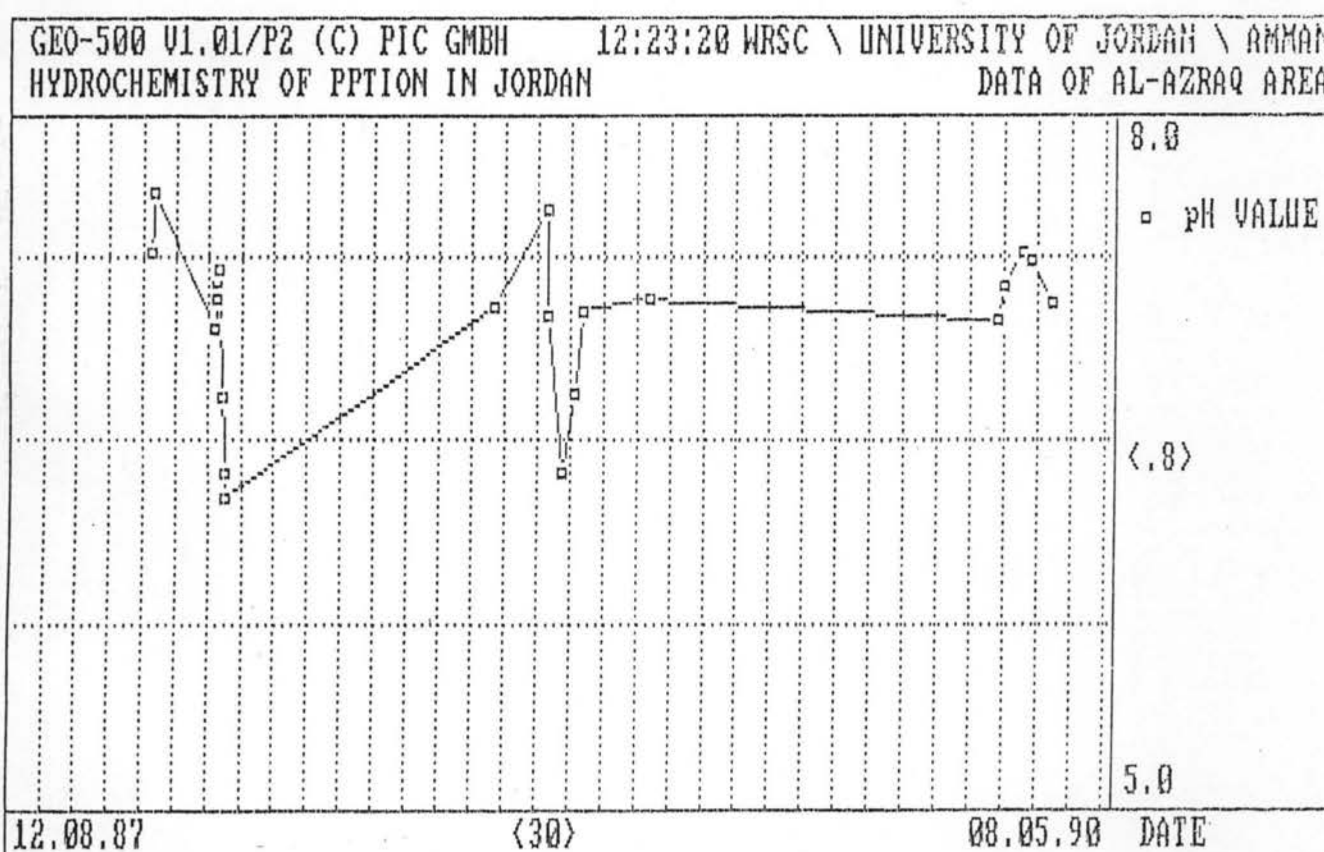
The pH-value of rain water samples collected from Azraq ranged between 6.34 and 7.67, with an average of 7.14 $\pm$ 0.34. Figure (41), shows the fluctuation in the pH-values of the collected samples . The maximum pH-value was measured on the 20th of December 1987 and the minimum on 24th of February 1988, where successive polar depressions affected Jordan.

4.3- Electrical conductivity (EC μs/cm).

The EC of the rain water samples collected from Azraq were found to be in the range of. 19.0 to 642 μs/cm. The average EC value was 277.7 $\pm$ 173.4 μs/cm. The EC fluctuations are presented



Figure(40): Fluctuations in ppt. Amounts for Azraq Station



Figure(41): Fluctuations in pH for Azraq Station in figure (42). The minimum EC of rain water was recorded on the 23rd of February 1988, when many rainy storms affected Jordan. While the maximum value was recorded on the 13th of March 1990.

4.4- Earth Alkaline elements, (Ca^{2+} + Mg^{2+})

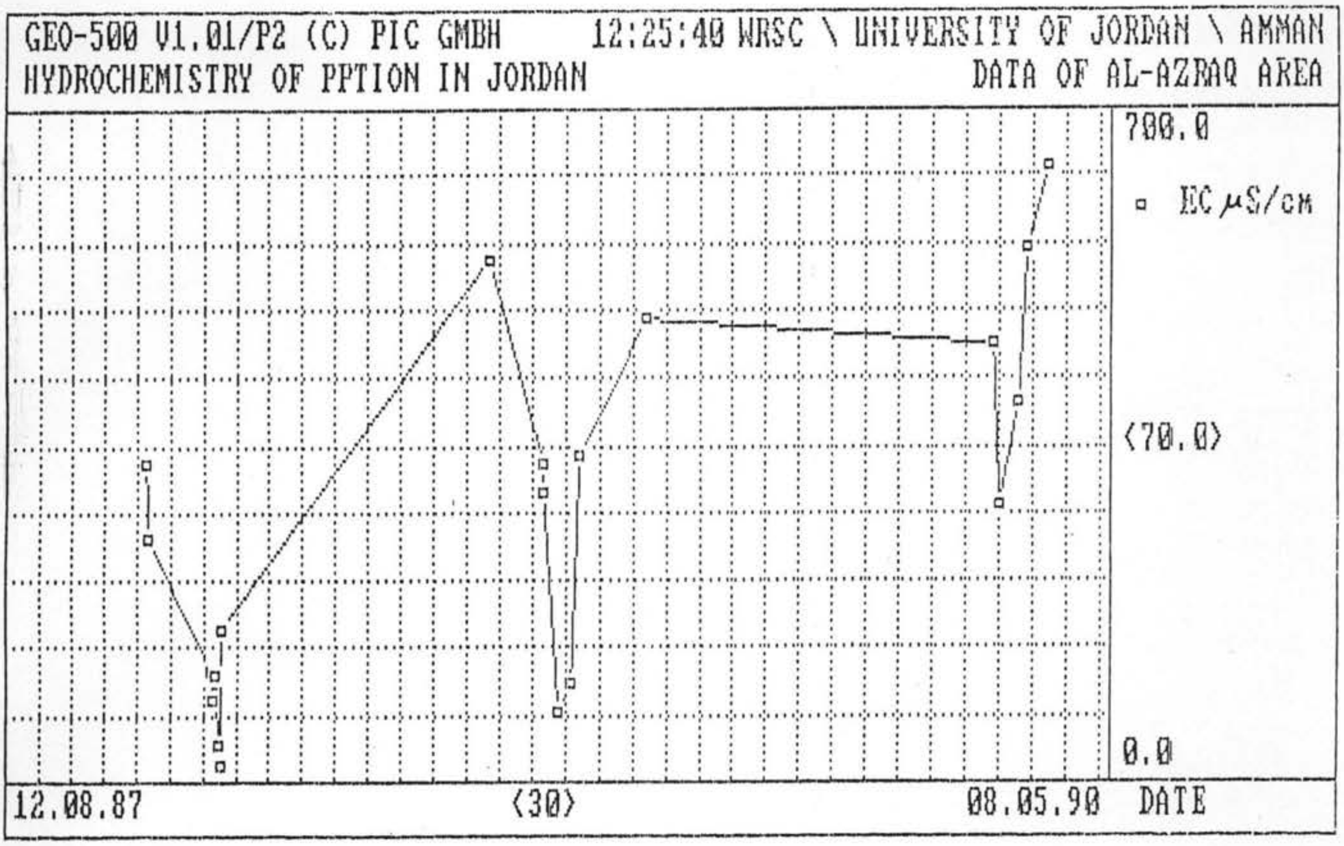
The earth alkaline elements in rain water in the area represented about 58.3 ± 145 % of the total cations and Calcium content, however was higher more than magnesium for all measured water samples. The calcium concentration ranged from 0.175 to 4.573 meq/l with an average of about 1.742 ± 1.164 meq/l. On the other hand, magnesium contents were found to range from 0.0, i.e. magnesium free water samples and 1.447 meq/l with an average of 0.322 ± 0.41 meq/l, figures (43 and 44), show the fluctuations in the calcium and magnesium concentrations respectively, during the study period.

4.5- Alkaline elements (Na^{+} & K^{+})

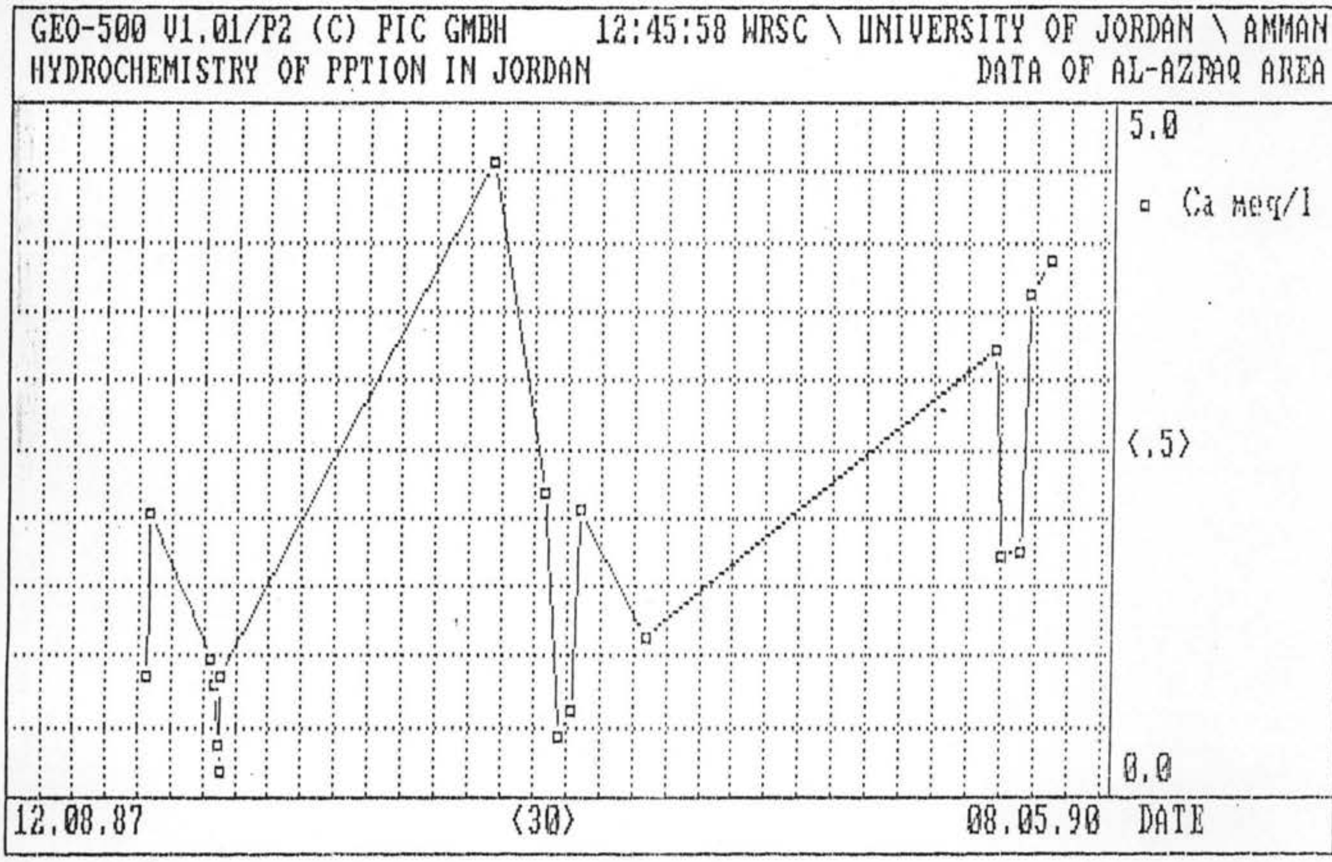
The sodium content ranged from 0.009 to 2.381 meq/l, with an average of about 0.606 ± 0.605 meq/l, figure (45). The maximum sodium content was measured on the 15th of January 1989. The potassium concentration was found to range from 0.001 to 0.149 meq/l, figure (46), and with an average value of 0.058 ± 0.047 meq/l. The average alkaline elements percentage was calculated to be 11.43 ± 7.24 % of the total cations.

4.6- Chloride (Cl^{-})

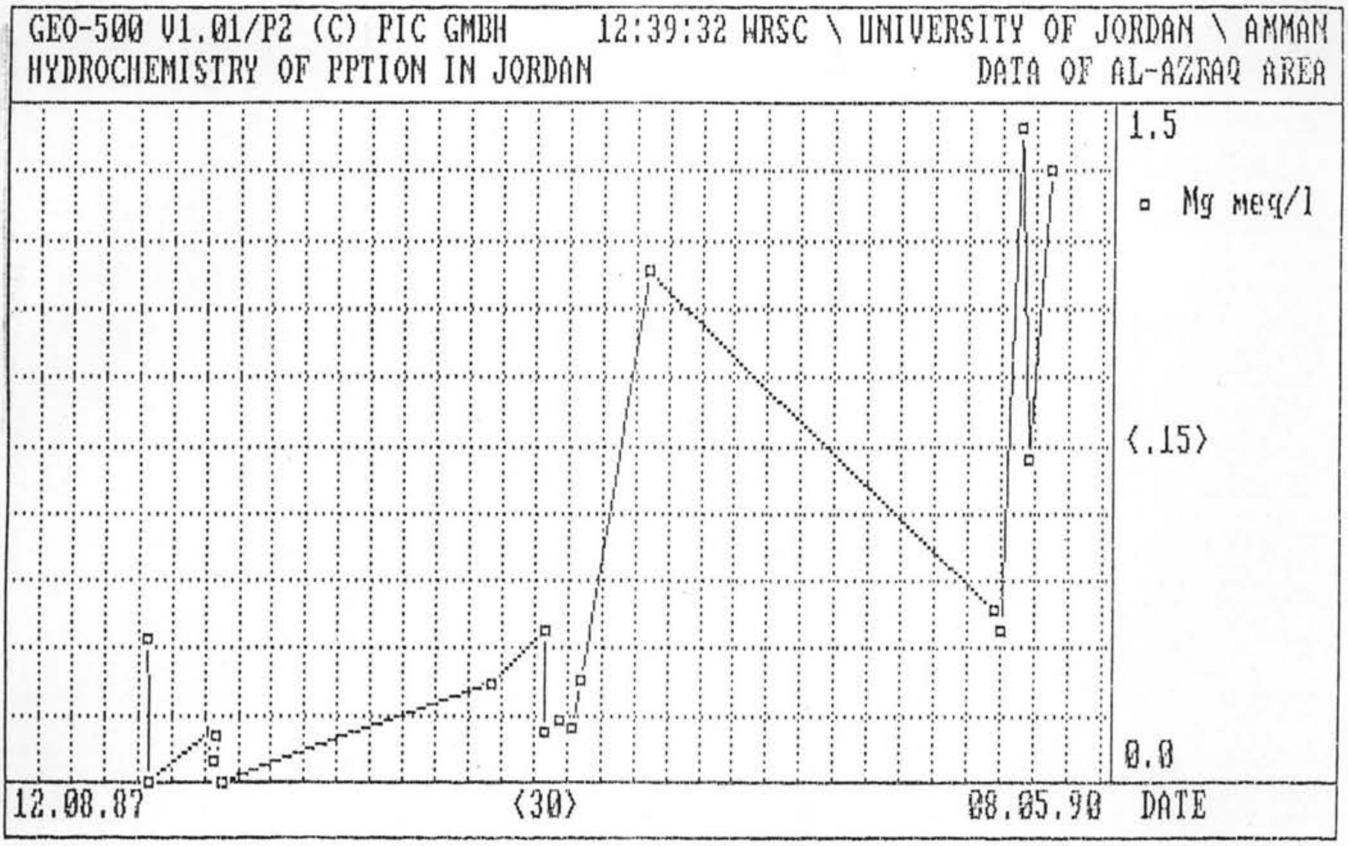
The chloride content varied between 0.06 and 1.95 meq/l, figure (47). The average content was 0.67 ± 0.55 meq/l. The



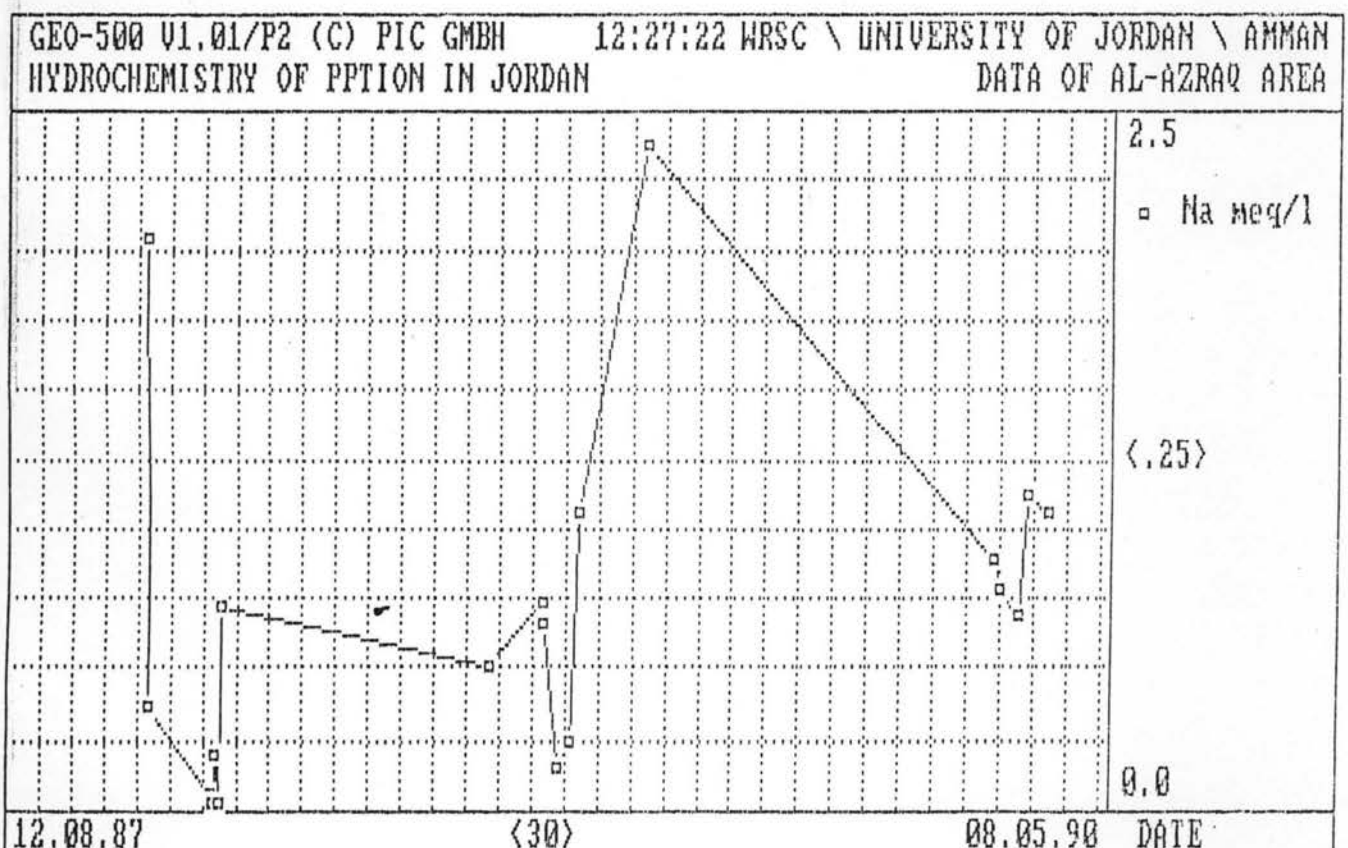
Figure(42): Fluctuations in EC for Azraq Station



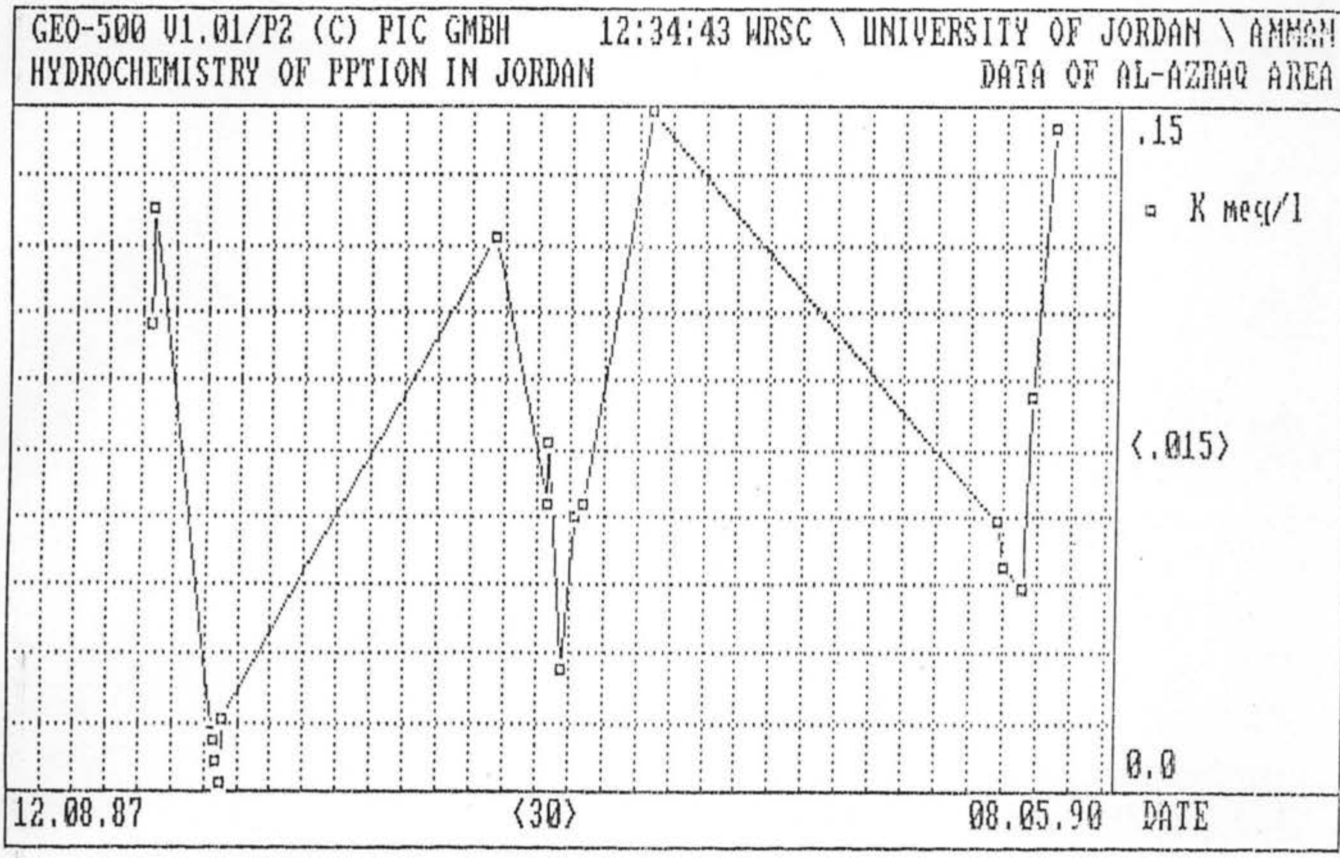
Figure(43): Fluctuations in Ca for Azraq Station



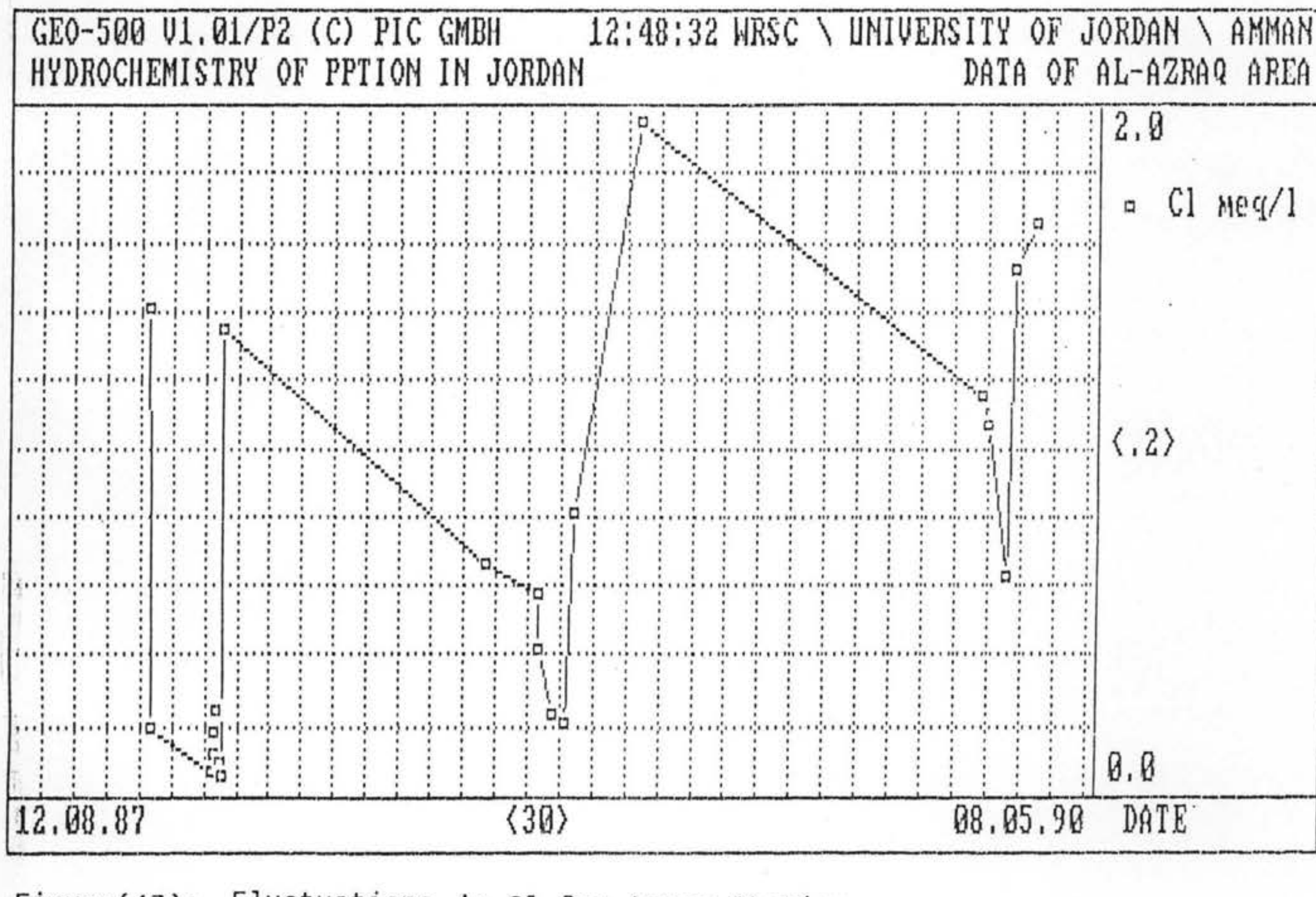
Figure(44): Fluctuations in Mg for Azraq Station



Figure(45): Fluctuations in Na for Azraq Station



Figure(46): Fluctuations in K for Azraq Station



Figure(47): Fluctuations in Cl for Azraq Station maximum chloride content was recorded on March, 13th 1990, while minimum value was measured on February, 23rd 1988.

4.7- Sulfate (SO_4^{2-})

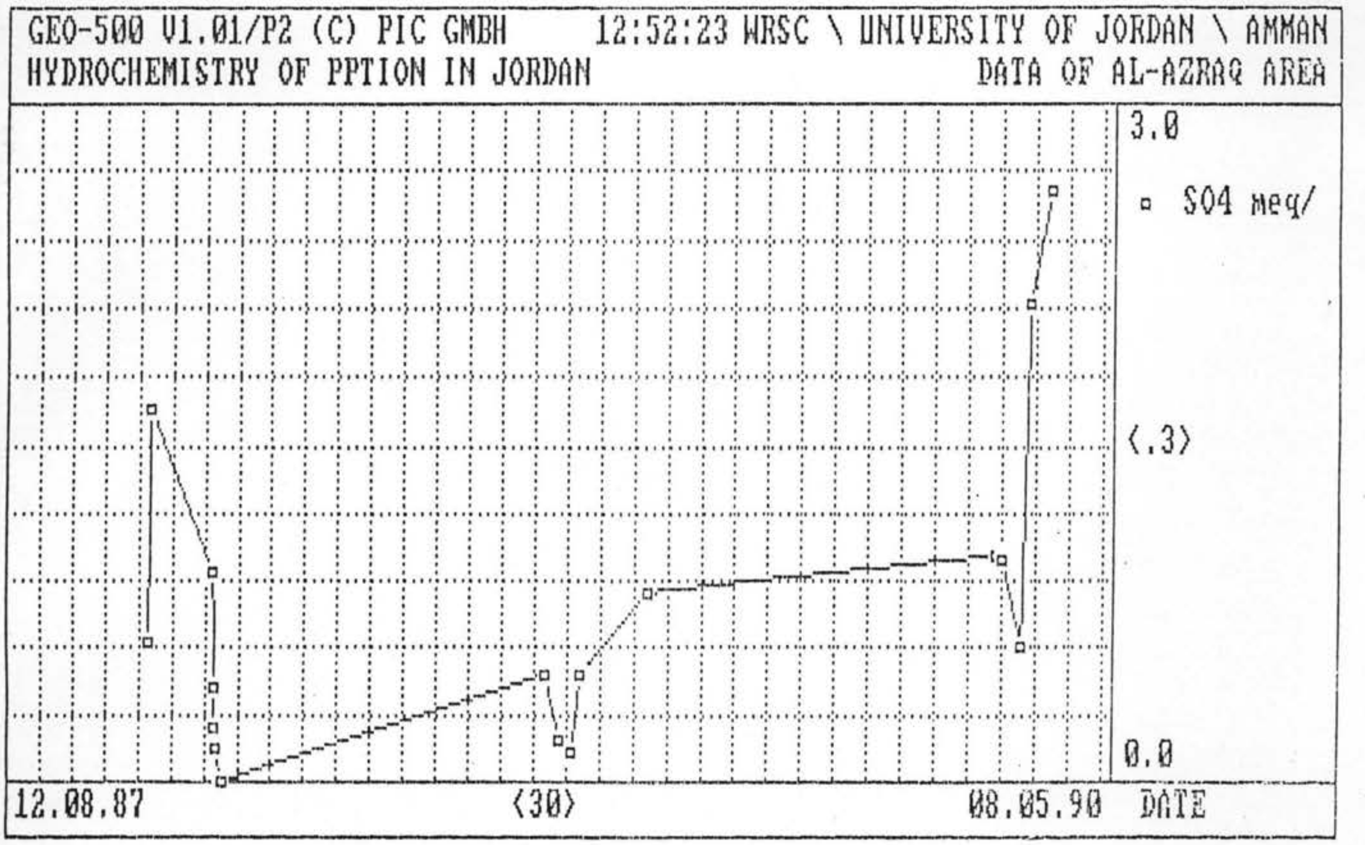
The sulfate content of rain water samples collected from Azraq ranged from sulfate free to 2.62 meq/l with an average value of 0.70 $\pm$ 0.69 meq/l. Figure (48), shows the sulfate fluctuations in rain water samples collected during the observation period. The maximum content was measured on the 13th of March 1990, during the invasion of Al-khamasien winds.

4.8- Nitrate (NO_3^-)

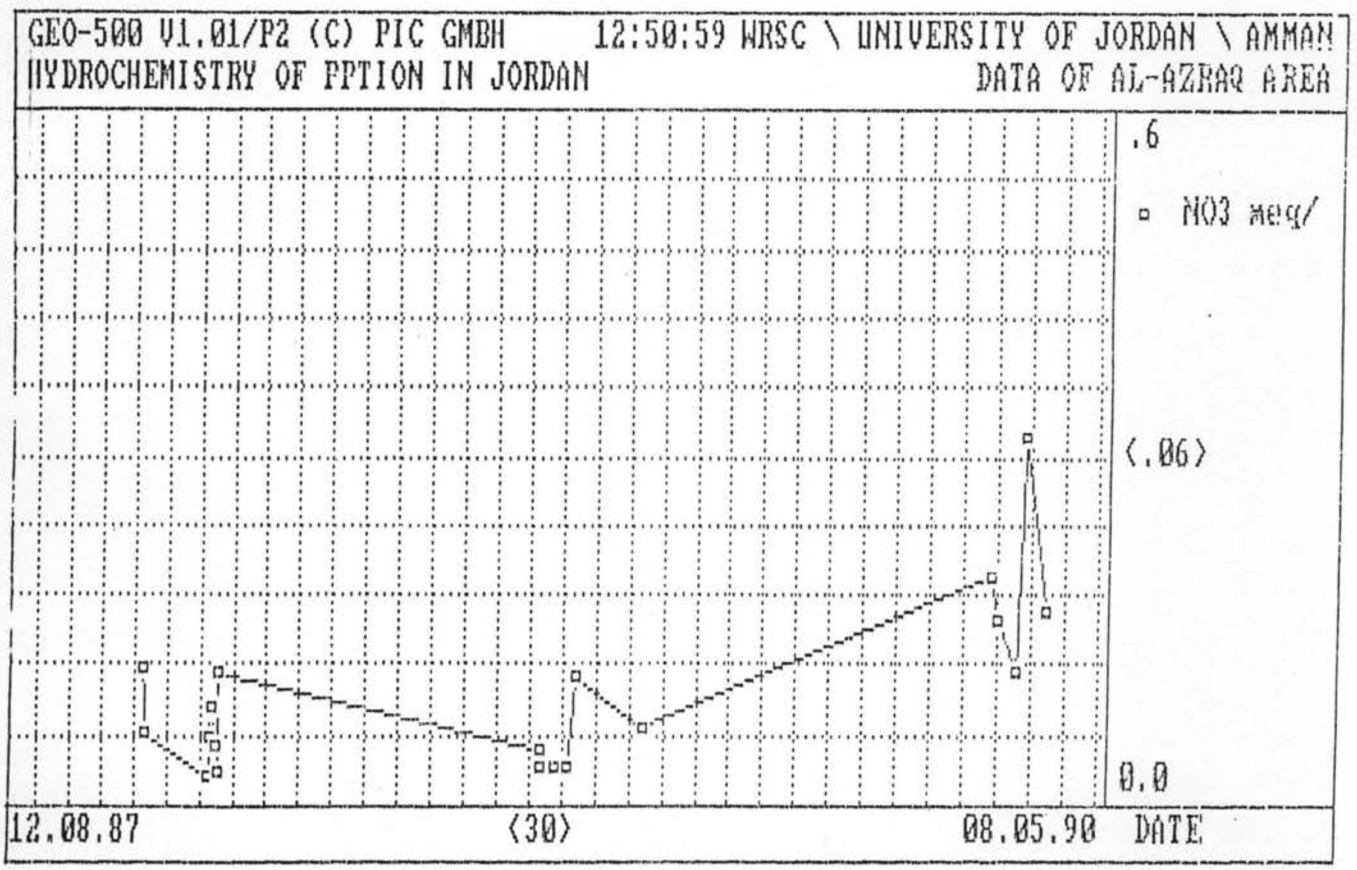
Nitrate fluctuations are represented in figures (49). The nitrate content were found to range from 0.025 to 0.56 meq/l with an average value of 0.11 $\pm$ 0.11 meq/l. The maximum nitrate content was measured on the 22nd of February 1990.

4.9- Bicarbonate (HCO_3^-)

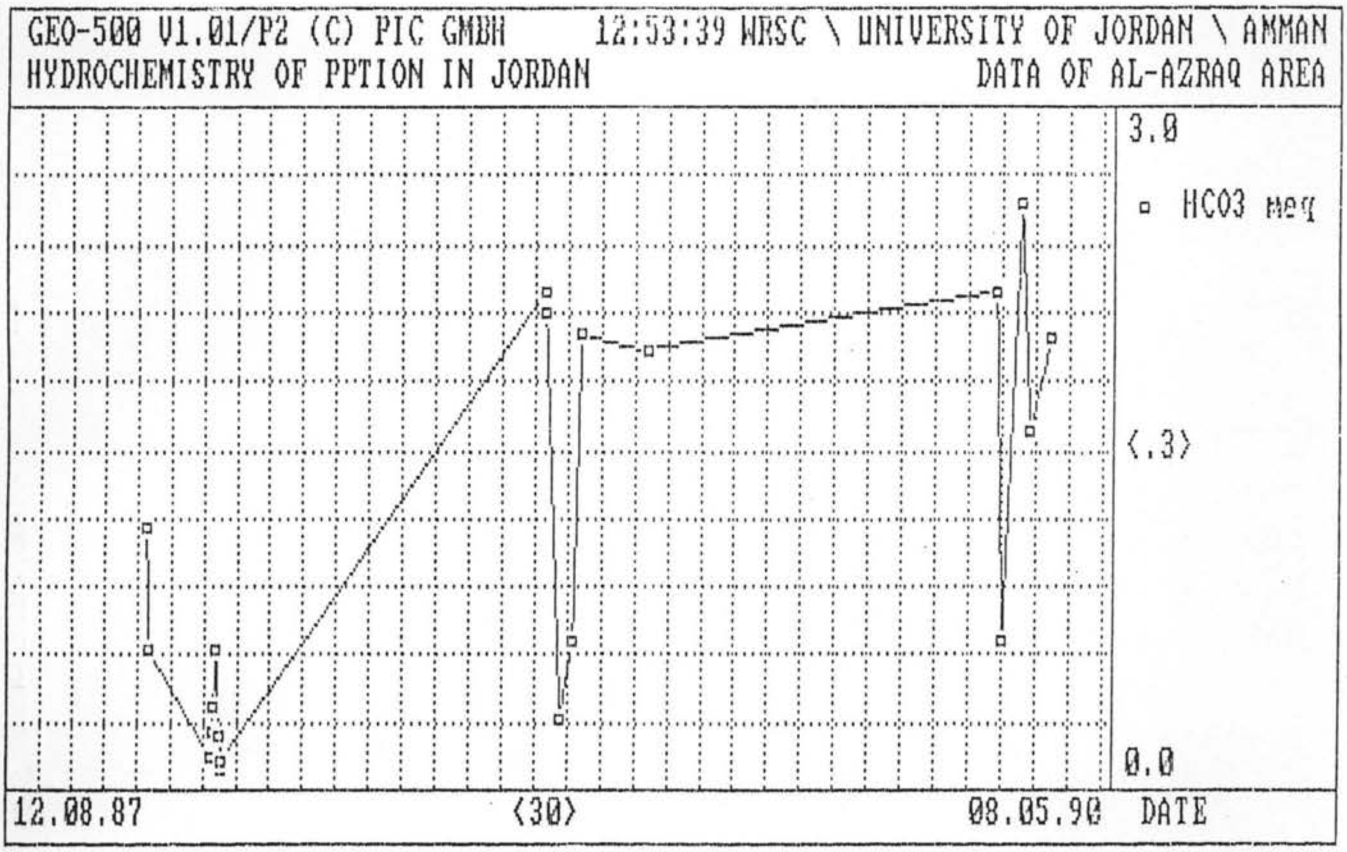
The bicarbonate content in ppt. samples collected from this area ranged from 0.10 to 2.73 mg/l , with an average value of 1.24 $\pm$ 0.86 meq/l figure (50). Bicarbonate ions represented the major anion present in the water followed by chloride and sulfate. The maximum bicarbonate concentration was measured on the 14th of February 1990.



Figure(48): Fluctuations in SO_4 for Azraq Station



Figure(49): Fluctuations in NO_3 for Azraq Station



Figure(50): Fluctuations in HCO_3 for Azraq Station

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HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-RABA VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32123.0	32917.0	32514.809	327.689
QUANT mm	0.1	39.0	6.879	7.601
TEMP °C	5.0	18.2	9.257	2.903
pH VALUE	5.80	8.80	7.5863	0.5978
EC µS/cm	20.0	415.0	114.350	68.025
Na meq/l	0.008	1.330	0.23192	0.28327
K meq/l	0.003	0.166	0.04788	0.04110
Mg meq/l	0.000	0.828	0.17703	0.17299
Ca meq/l	0.000	2.394	0.68669	0.41479
Cl meq/l	0.082	1.513	0.39788	0.26715
NO3 meq/	0.001	0.496	0.05640	0.07675
SO4 meq/	0.046	0.779	0.22112	0.17365
HCO3 meq	0.049	1.362	0.46812	0.33304
TC meq/l	0.201	4.150	1.14351	0.68023
Ta meq/l	0.200	4.150	1.14350	0.68025
I mg/l	0.000	0.261	0.02184	0.04627
Br mg/l	0.000	0.380	0.05754	0.08226
F mg/l	0.008	0.153	0.05017	0.04410
PO4 mg/l	0.011	1.967	0.46454	0.47741
TOC mg/l				
Li mg/l	0.000	0.112	0.03176	0.03258
TURBIDY	0.0	80.0	13.022	17.513
COLOR	0.4	100.0	24.860	26.993
TDS 104°	0.060	0.150	0.10200	0.02700
TDS 180°	0.050	0.130	0.08750	0.02372
Ag mg/l	0.00000	0.01900	1.870E-03	3.967D-03
TIME hr				
Fe mg/l	0.00710	2.66100	2.642E-01	6.727D-01
Cu mg/l	0.00000	0.01100	1.669E-03	3.338D-03
Mn mg/l	0.00000	0.23000	1.883E-02	5.862D-02
Zn mg/l	0.00000	0.12100	3.799E-02	4.129D-02
Pb mg/l	0.00000	0.00440	1.303E-03	1.652D-03
Cr mg/l	0.00000	0.00750	7.133E-04	1.965D-03
Ni mg/l	0.00000	0.00000	0.000E+00	0.000D+00
Sr mg/l	0.06100	0.07900	7.000E-02	1.273D-02

Table(5): Descriptive Statistics for Rabba Station

5- Rabba Station

Forty two rain samples were collected by the employees of Rabba weather station during the study period. This station represents the rain water quality falling on the Middle part of Jordan (south of Wadi Ragib) along with the lands to the east of the Dead Sea. The descriptive statistics of the analysed parameters are represented in table (5).

Concentrations and Fluctuations in the Measured Parameters:

5.1- Amount of rainfall (mm):

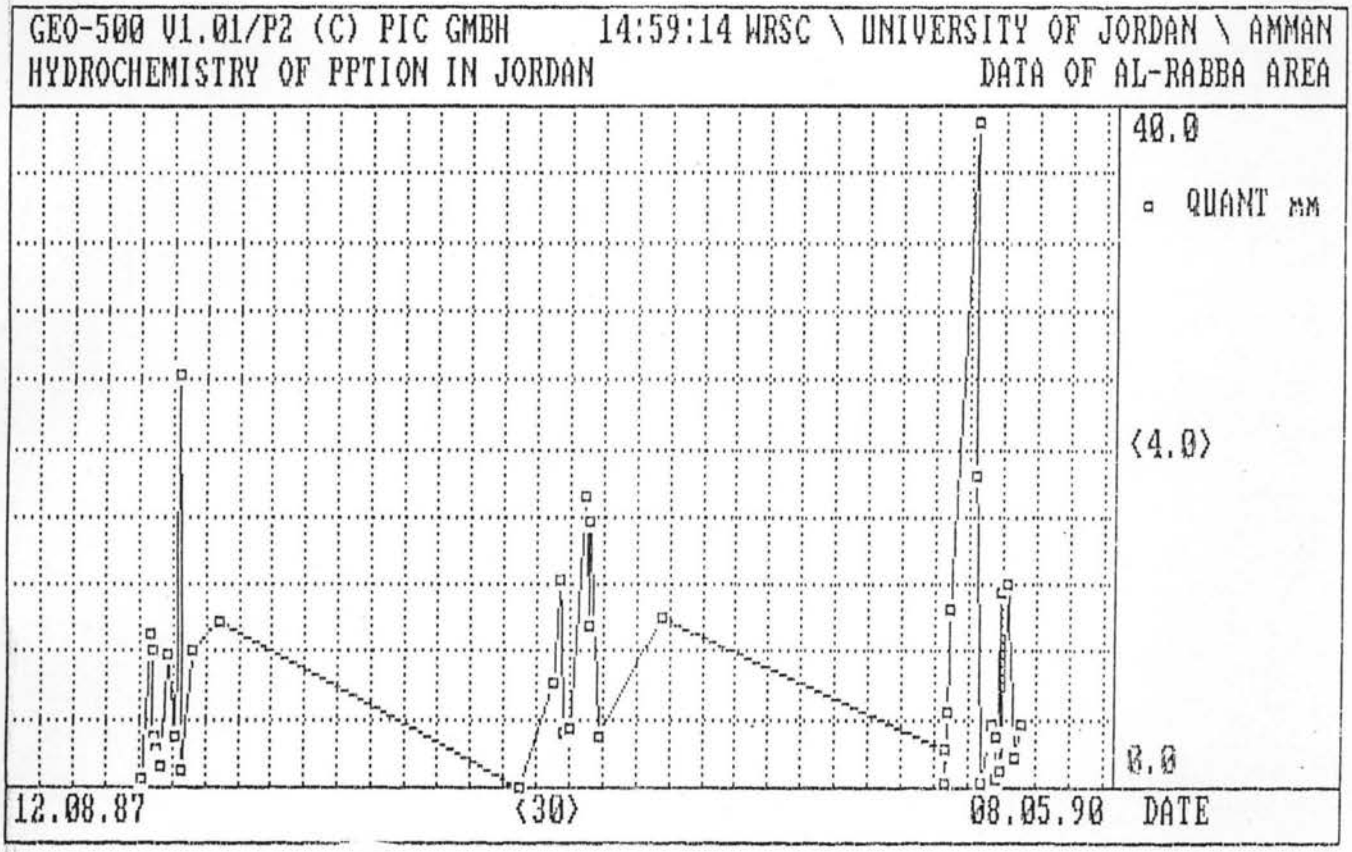
The analysed samples were collected from rain storms ranging from 0.1 to 39 mm. The fluctuations in the amount of ppt. in Rabba are presented in figure (51). The highest amount of ppt. was recorded on the 3rd of January 1989, where successive polar depressions affected Jordan.

5.2- Temperature

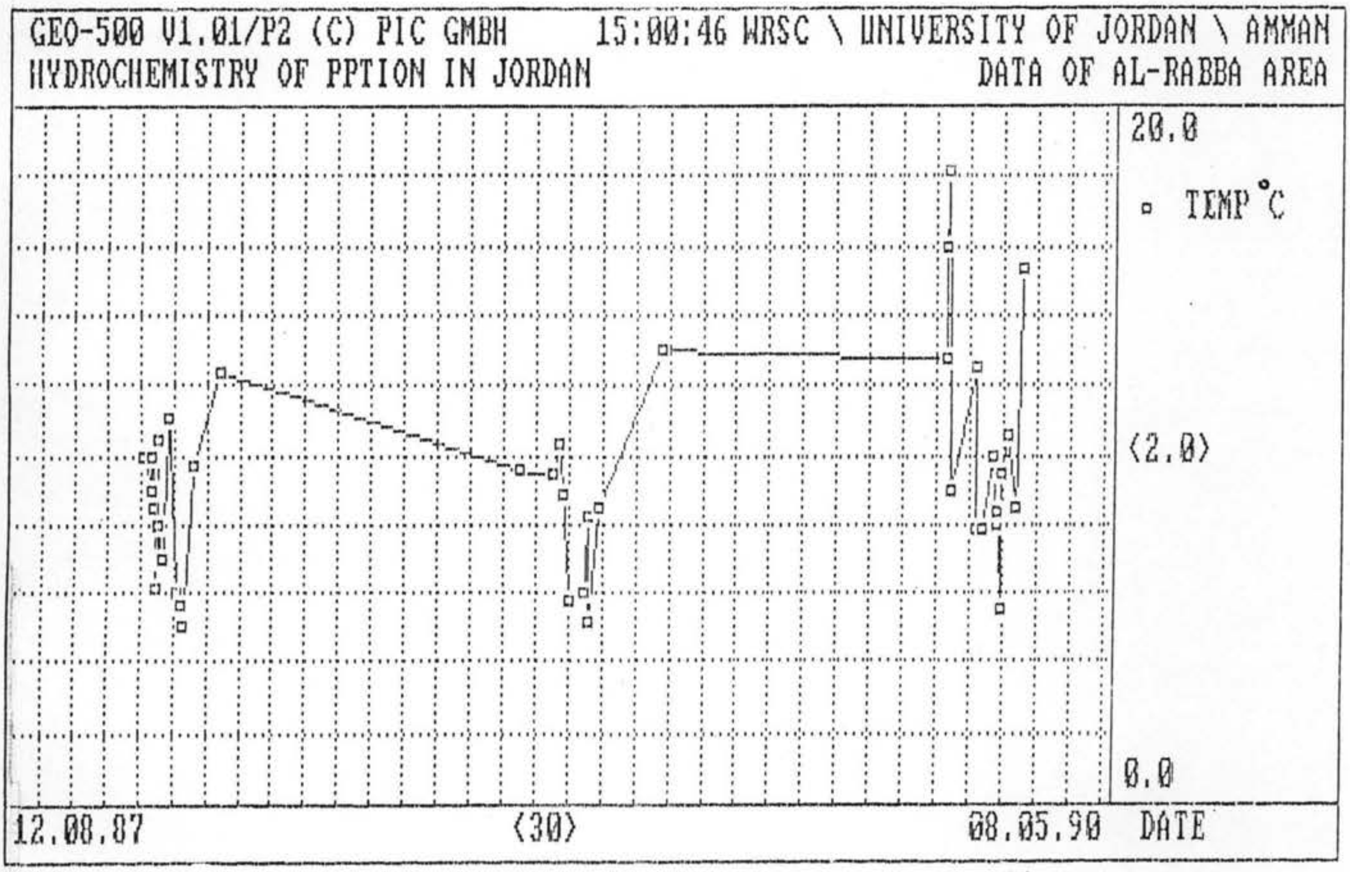
The temperature of rain water samples were found to range from 5.0 to 18.2 C, with an average of 9.3 $\pm$ 2.9 C^{O}, figure (52). The maximum temperature was measured in rainfall collected on the 11th of December 1989, whereas the minimum temperature was recorded on the 18th of December 1988.

5.3- pH-value.

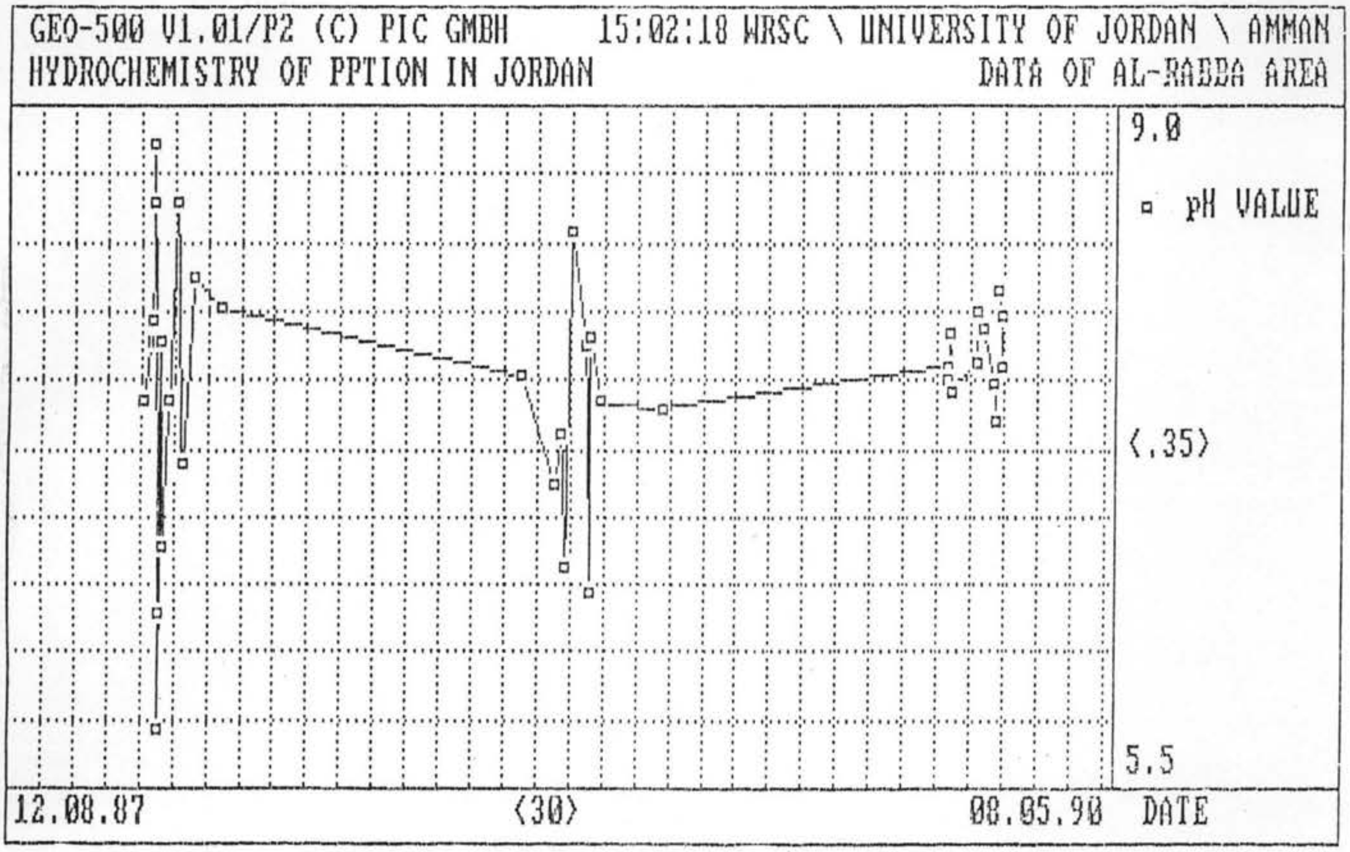
The pH-value of rain water samples collected from Rabba were found to range from 5.8 to 8.80, with an average of 7.58 $\pm$ 0.6. Figure (53), shows the fluctuations in the pH-value of rain water samples collected during the study period. The minimum pH-value was recorded on the 26th of December 1987. When successive polar



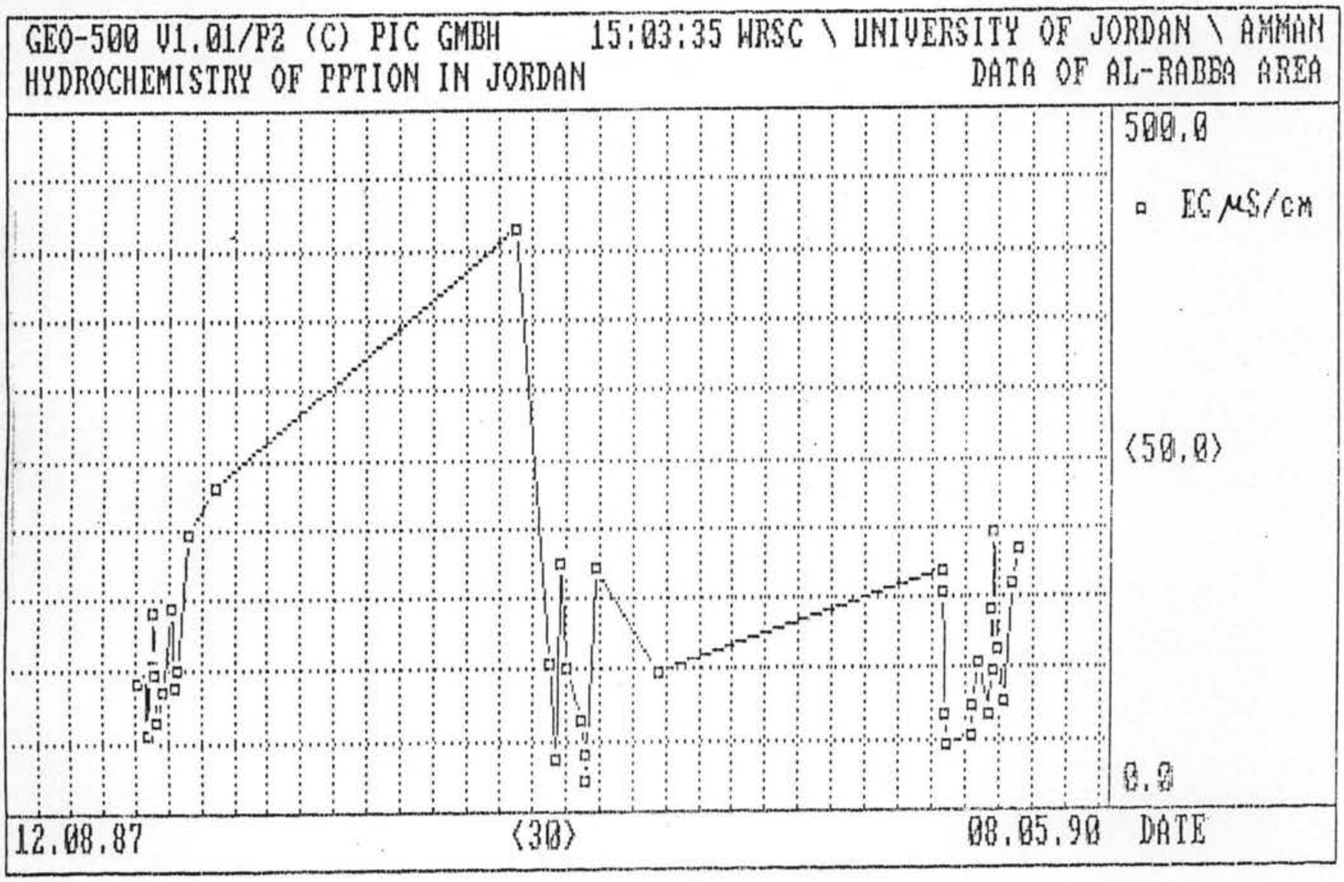
Figure(51): Fluctuations in ppt. Amounts for Rabba Station



Figure(52): Fluctuations in Temperature for Rabba Station



Figure(53): Fluctuations in pH for Rabba Station



Figure(54): Fluctuations in EC for Rabba Station rainy depressions affected Jordan.

5.4- Electrical Conductivity (EC μs/cm)

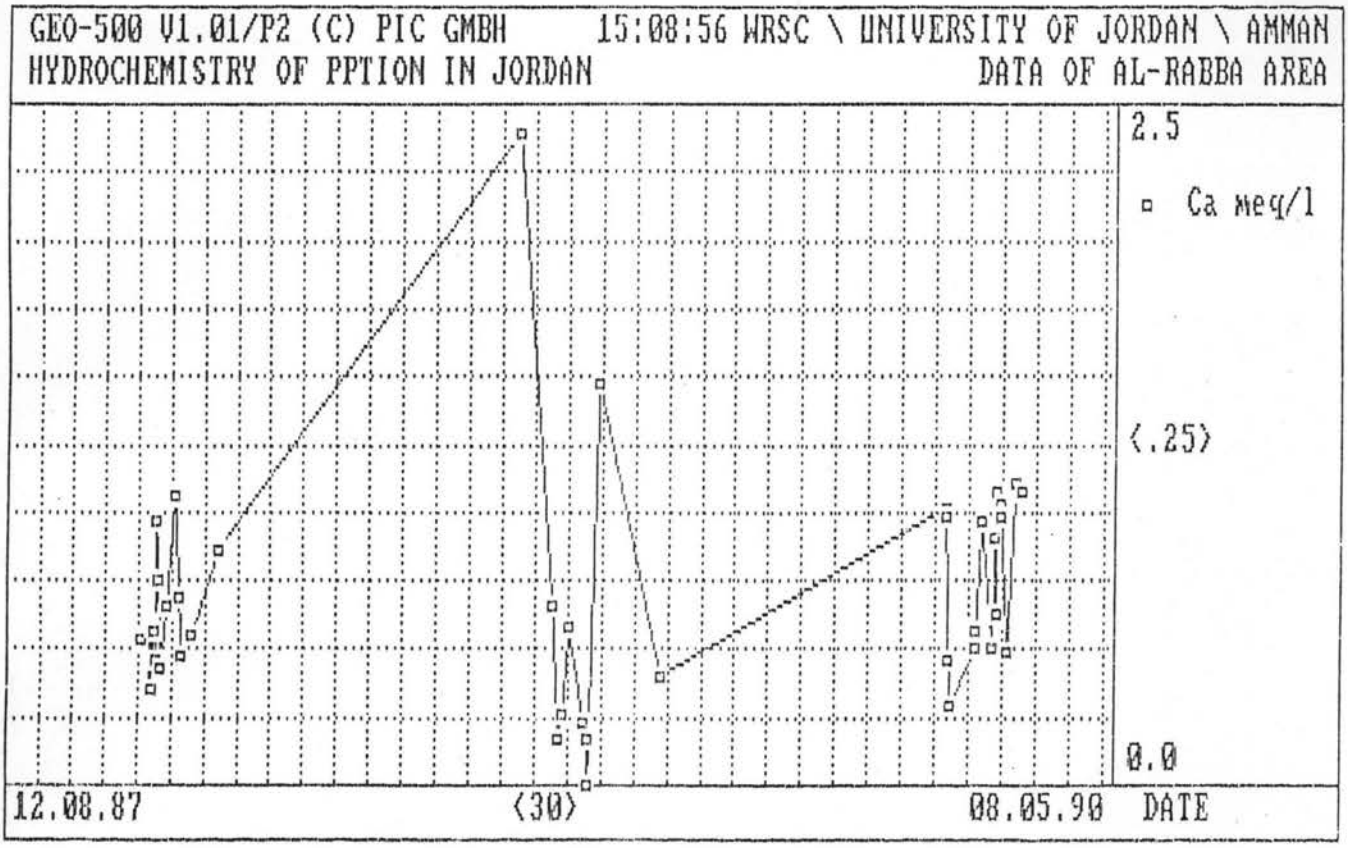
The EC of ppt. water ranged from 20 to 415 μs/cm with an arth. mean of 114.4 ± 68 μs/cm, figure (54). The maximum measured EC of rain water samples was recorded at the beginning of the rainy season 1988/1989, when the minimum a mount of rainfall was recorded. The minimum electrical conductivity of rainfall was recorded during the same rainy season on the 21st of January 1989.

5.5- Earth Alkaline Elements (Ca^{+} & Mg^{+})

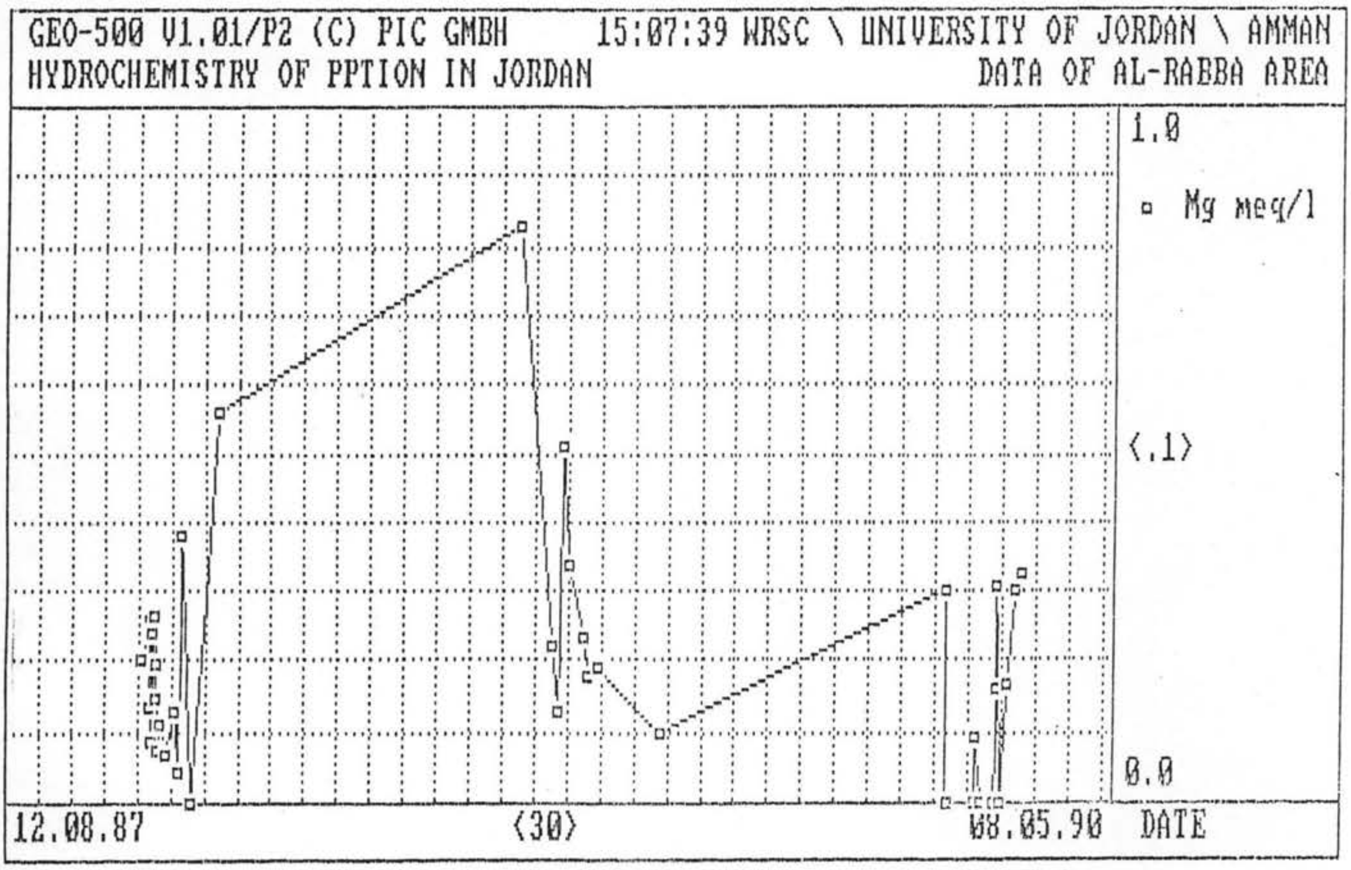
Similar to other stations, the earth alkaline elements represent the major dominant cations with more than 75 % of the total cations. The calcium concentrations in ppt. water samples were found to range from calcium free water to 2.39 meq/l, with an arth. mean of 0.69 ± 0.41 meq/l, figure (55). Magnesium content, however, ranged between Mg-free water and 0.83 meq/l, with an average of 0.18 ± 0.17 meq/l, figure (56). The maximum Ca and Mg were recorded for ppt. water sample collected on the 19th of February 1988, whereas magnesium free rain water samples were recorded many times during the study period.

5.6- Alkaline Elements Na^{+} & K^{+}

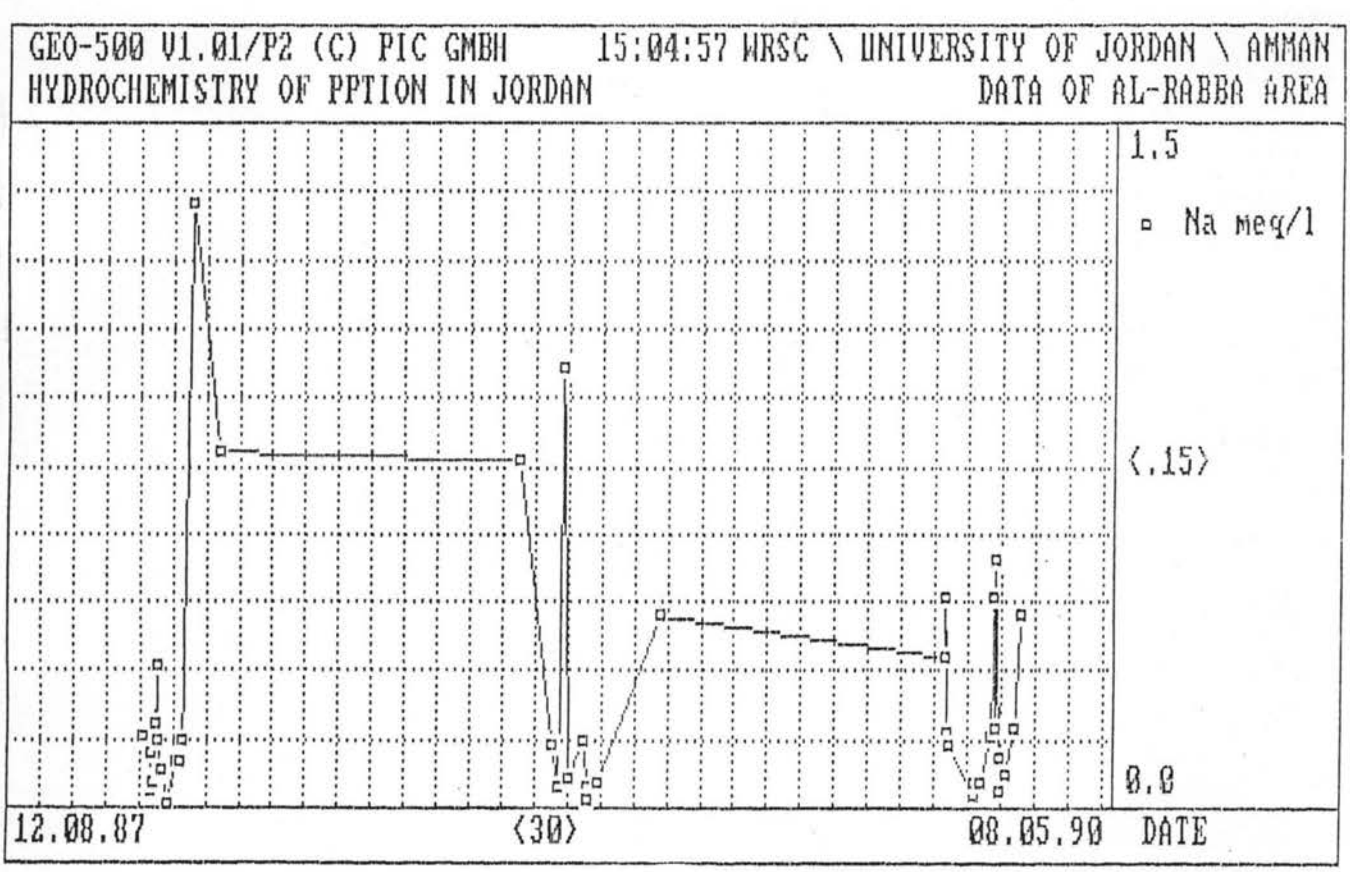
The fluctuations in the sodium and potassium contents of rain water samples are represented in figures (57 and 58). The sodium ion represents the second major cation in ppt. water collected from Rabba area. The sodium content ranged from 0.01



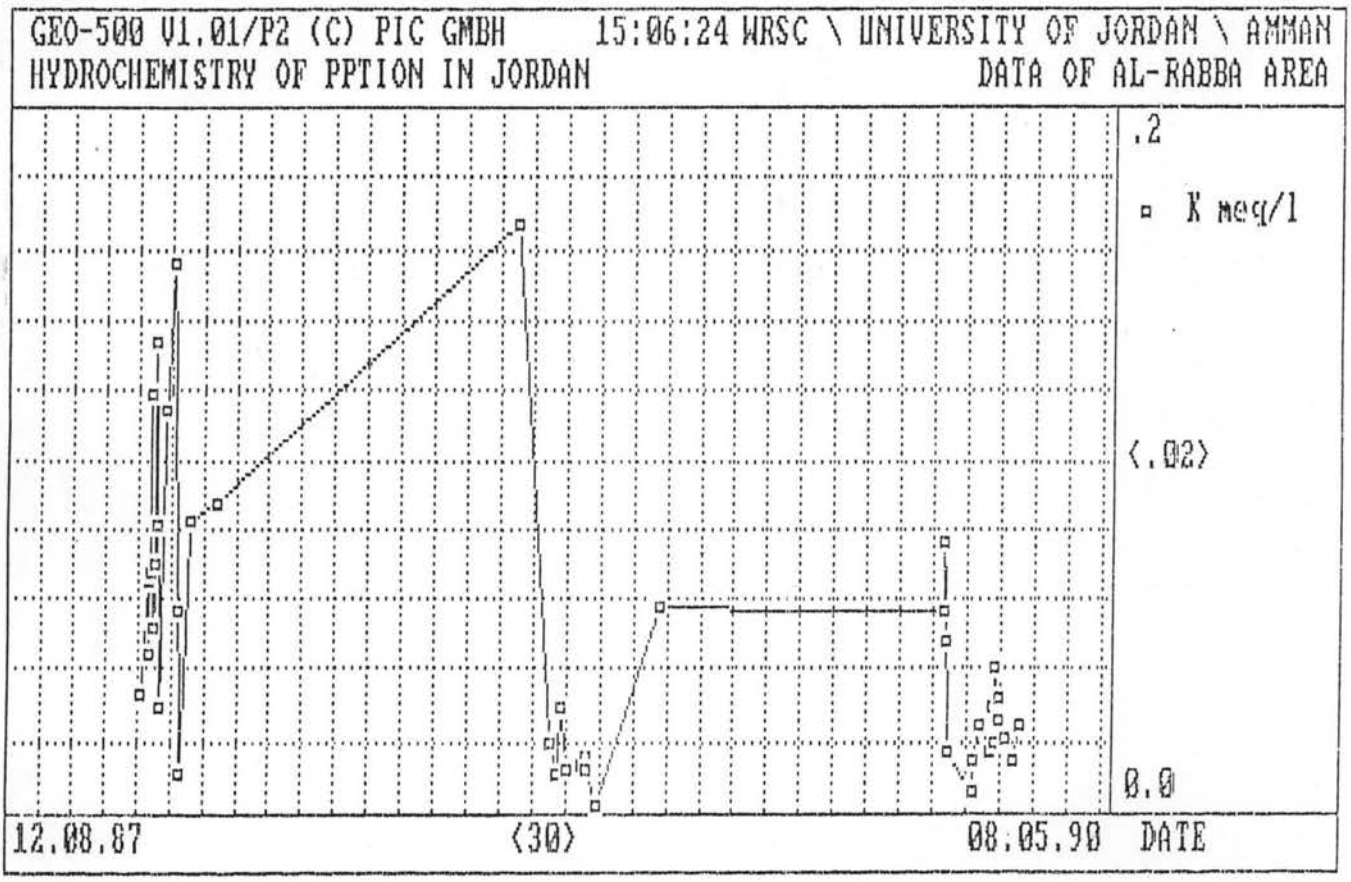
Figure(55): Fluctuations in Ca for Rabba Station



Figure(56): Fluctuations in Mg for Rabba Station



Figure(57): Fluctuations in Na for Rabba Station



Figure(58): Fluctuations in K for Rabba Station to 1.33 meq/l with an average of 0.23 meq/l, whereas the potassium content was found to range from 0.003 to 0.166 meq/l, with an arth. mean 0.05 ± 0.04 meq/l. The maximum sodium concentration was recorded on the 26 of January 1988, at the beginning of deep polar depression which affected Jordan more towards the south and the south east. The maximum potassium content was measured at the beginning of the rainy season of 1988/1989.

5.7- Chloride Cl^-

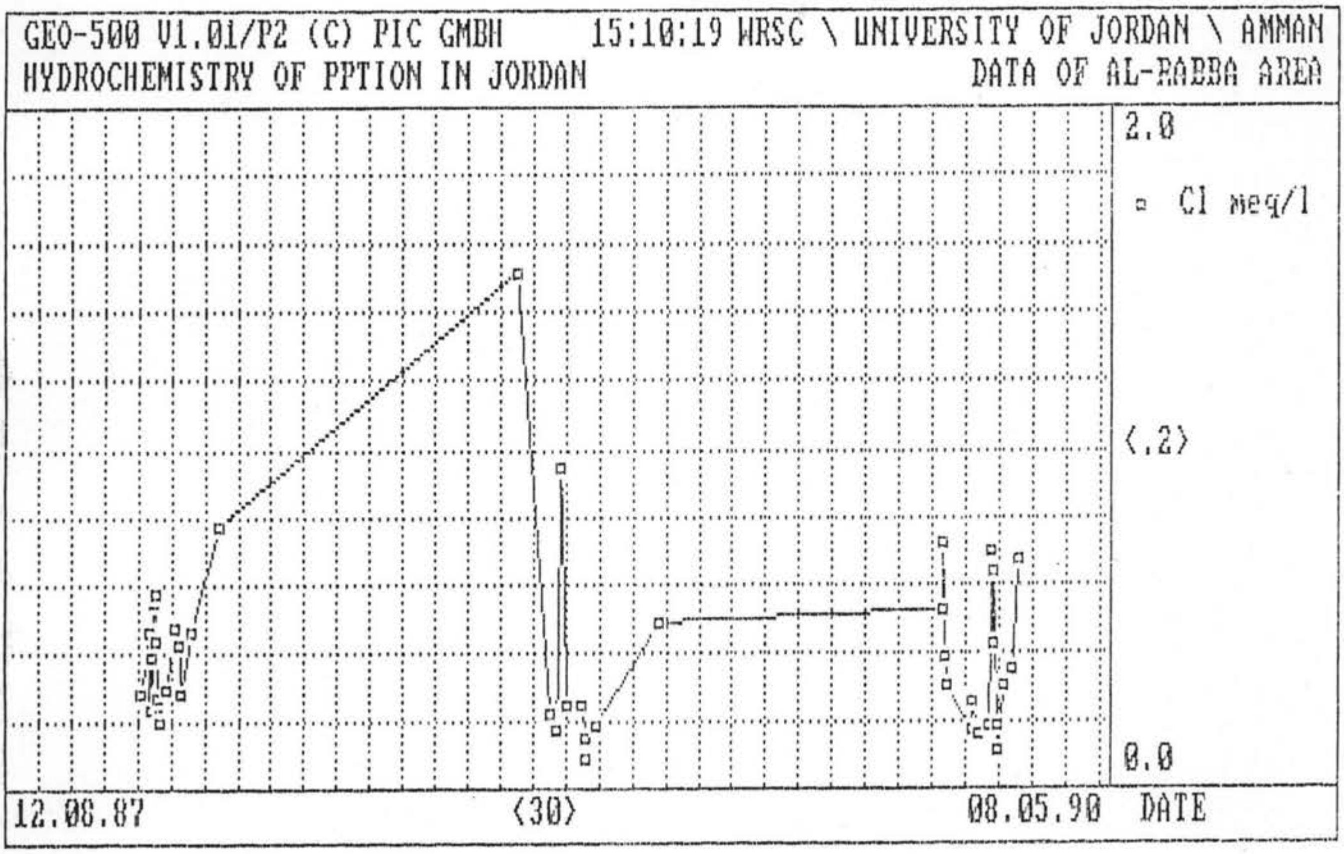
The chloride content ranged from 0.08 to 1.51 meq/l, with an arth. mean of 0.40 ± 0.27 meq/l, figure (59). The maximum concentration was measured in a rain water sample collected on the of 19th November 1988 at the beginning of the rainy season coinciding with those of K, Mg and EC.

5.8- Sulfate SO_4^{2-}

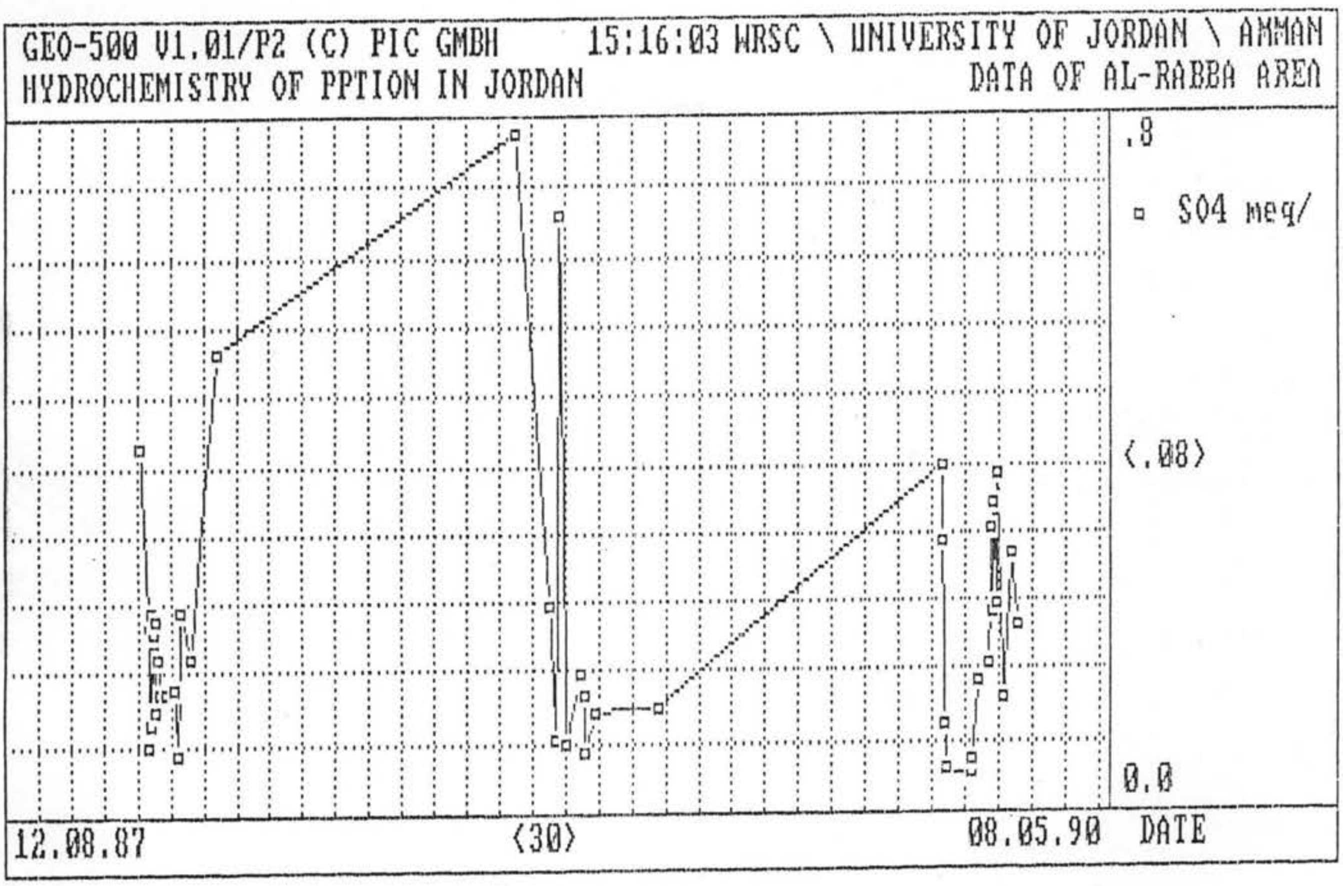
The sulfate concentration in rain water samples collected from Rabba was found to range from 0.05 to 0.78 meq/l. The average content in ppt. water was 0.22 ± 0.17 meq/l figure (60), shows the fluctuations in the sulfate content in ppt. water during the study period. Similar to most ions (Cl, K, Mg, Ca), maximum sulfate content was measured at the beginning of the rainy season of the hydrologic year 1988/1989.

5.9- Nitrate NO_3^-

The nitrate contents of ppt. water was found to range from almost nitrate free water to 0.50 meq/l, with an average of about 0.06 meq/l. The maximum nitrate content was measured on the



Figure(59): Fluctuations in Cl for Rabba Station



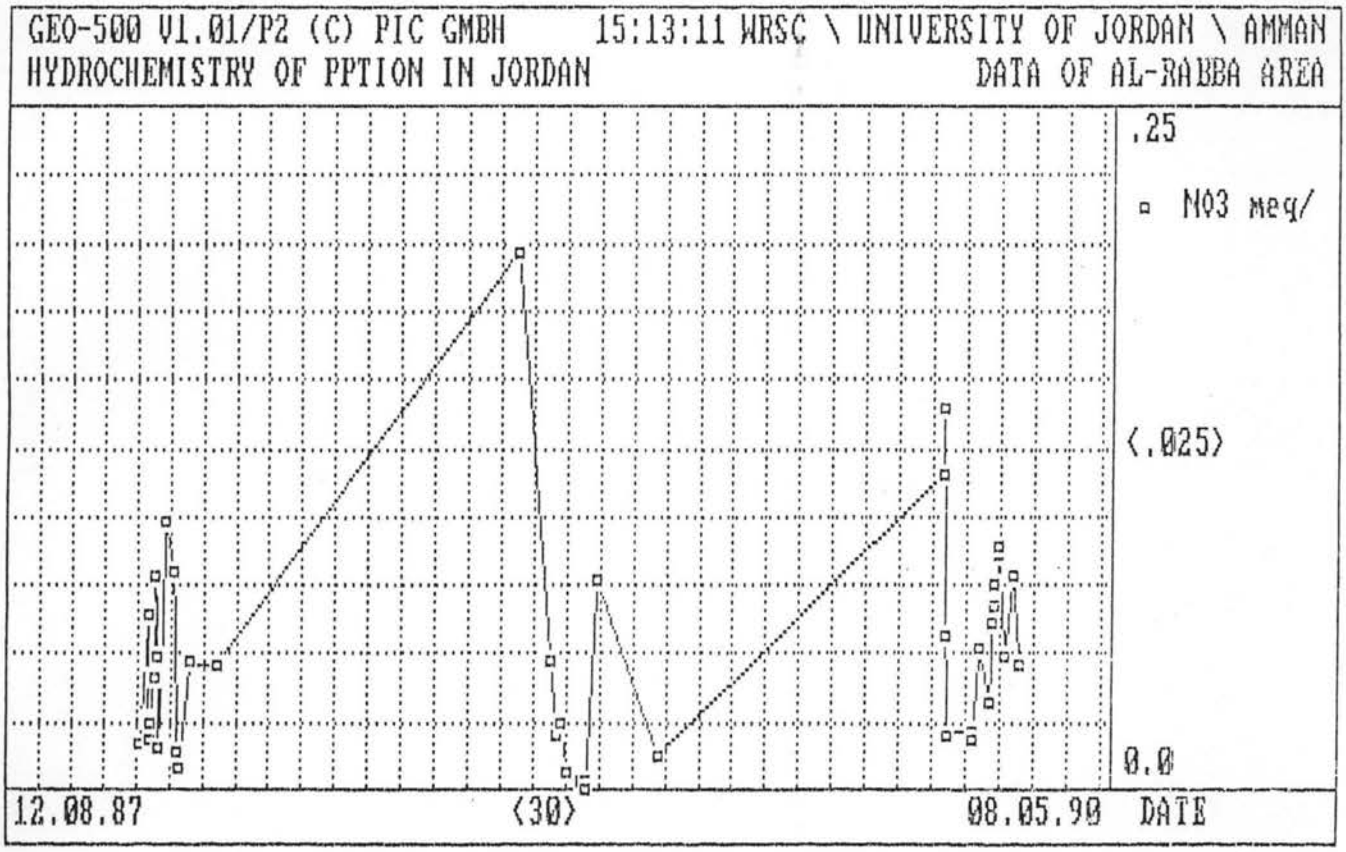
Figure(60): Fluctuations in SO_4 for Rabba Station

19th of November 1988. The fluctuations in the nitrate content of rain water samples are represented in figure (61).

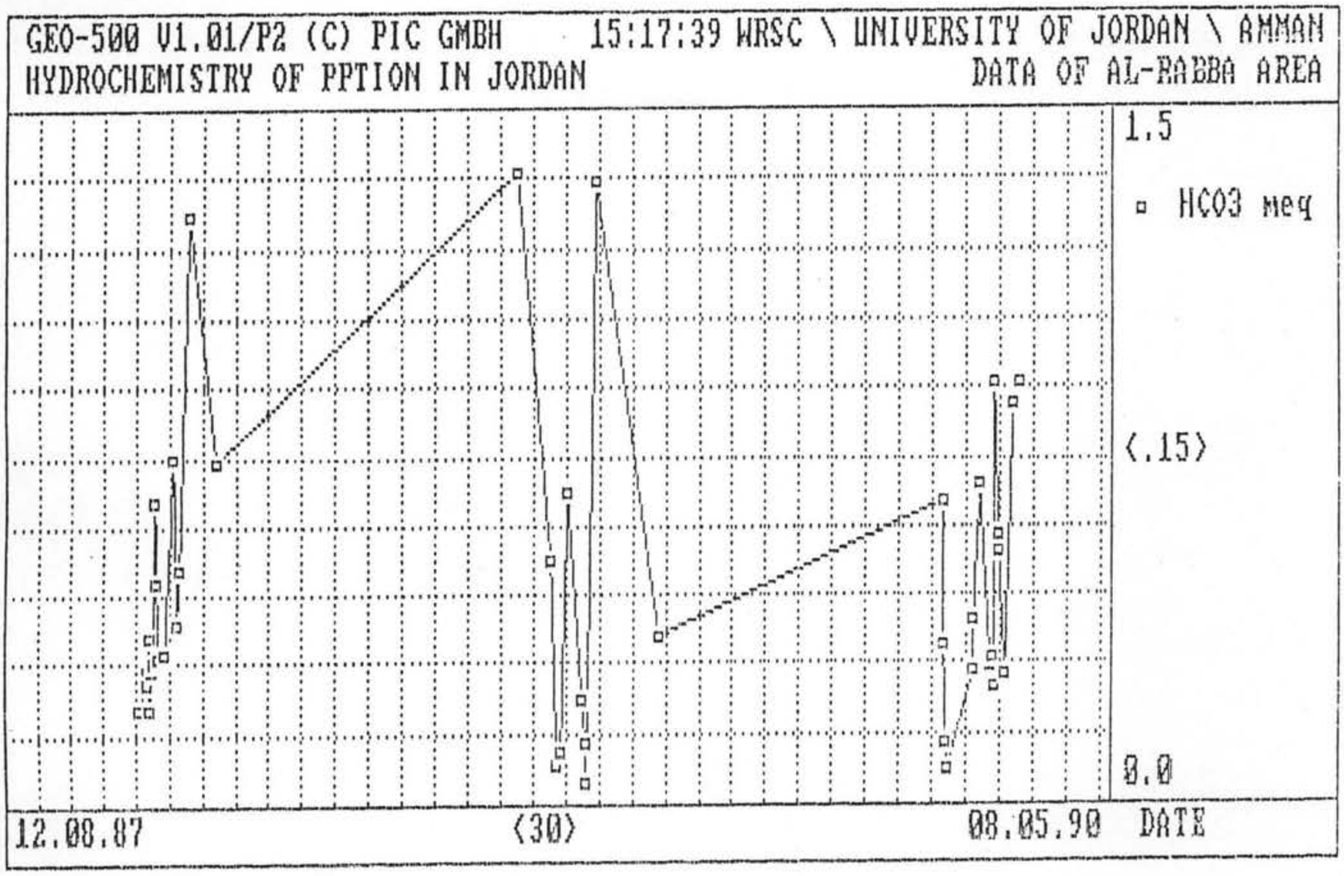
5.10- *Bicarbonate (HCO_3^-)*

The bicarbonate ion represented the major anion in ppt. water samples, forming about 40 % of the total anions. These bicarbonate content correlates directly with calcium. The HCO_3 concentration in rain water samples collected during the study period was found to range from 0.05 to 1.36 meq/l, with an average of 0.47 $\pm$ 0.33 meq/l, figure (62). The maximum HCO_3 content was measured on the 19th of November 1988, while the minimum concentration was recorded on the 21st of January 1989 of the same hydrologic year.

In the southern part of Jordan two stations were chosen to collect rain water samples , the first is the Shobak weather station and the second is the Marine station in Aqaba. During the study period only two samples were collected from Aqaba, since most of the rain water evaporated before collection due to the little amount of accumulated rainfall. From Shobak weather station only six monthly composite samples were collected and analysed. The descriptive statistics of the analysed parameters are shown in table (6). The different values represented the weighted average of each amount collected from each storm affecting the area during one month.



Figure(61): Fluctuations in NO_3 for Rabba Station



Figure(62): Fluctuations in HCO_3 for Rabba Station

STASY V7.02/12 (C) PIC GMBH WRSC UNIV.JORDAN 13.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-SHBK VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32141.0	32873.0	32362.500	300.012
pH VALUE	7.05	7.70	7.3117	0.3013
EC µS/cm	48.0	151.0	96.500	36.462
Na meq/l	0.011	0.403	0.16586	0.13617
K meq/l	0.000	0.027	0.00910	0.01023
Mg meq/l	0.058	0.372	0.16805	0.11467
Ca meq/l	0.386	0.900	0.62195	0.18831
Cl meq/l	0.106	0.504	0.27917	0.16321
NO3 meq/	0.020	0.076	0.05100	0.02362
So4 meq/	0.050	0.384	0.20741	0.13252
HCO3 meq	0.154	0.751	0.42747	0.23906
TC meq/l	0.480	1.510	0.96500	0.36462
TA meq/l	0.480	1.510	0.96500	0.36462
I mg/l	0.001	0.018	0.00700	0.00765
Br mg/l	0.005	1.380	0.34060	0.58350
F mg/l	0.032	0.105	0.07867	0.04053
PO4 mg/l	0.000	0.734	0.24633	0.42234
Li mg/l	0.010	0.030	0.02133	0.01026
TURBIDY	0.0	28.0	14.000	19.799
COLOR	0.0	8.0	3.000	4.359
Fe mg/l	0.00000	0.03230	1.077E-02	1.865D-02
Cu mg/l	0.00000	0.00580	1.933E-03	3.349D-03
Mn mg/l	0.00000	0.00160	5.333E-04	9.238D-04
Zn mg/l	0.00000	0.00167	5.567E-04	9.642D-04
Pb mg/l	0.00110	0.00530	2.667E-03	2.294D-03
Cr mg/l	0.00000	0.00000	0.000E+00	0.000D+00
Ni mg/l	0.00000	0.00000	0.000E+00	0.000D+00

Table(6): Descriptive Statistics for Shobak Station

STASY V7.02/12 (C) PIC GMBH WRSC UNIV.JORDAN 10.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-SALT VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32071.0	32964.0	32329.770	311.500
QUANT mm	0.2	57.0	10.210	13.857
TEMP °C	6.2	16.7	10.813	3.932
pH VALUE	6.39	8.74	7.6074	0.5676
EC µS/cm	18.0	372.0	98.679	71.503
Na meq/l	0.000	2.245	0.31673	0.45242
K meq/l	0.004	0.322	0.04641	0.06208
Mg meq/l	0.000	0.456	0.15719	0.11318
Ca meq/l	0.101	1.033	0.46647	0.25779
Cl meq/l	0.045	2.205	0.42247	0.43436
NO3 meq/	0.004	0.214	0.05718	0.05128
SO4 meq/	0.031	0.900	0.18823	0.19396
HCO3 meq	0.095	0.719	0.31892	0.15519
TC meq/l	0.180	3.720	0.98680	0.71503
TA meq/l	0.180	3.720	0.98679	0.71503
I mg/l	0.000	0.060	0.00637	0.01122
Br mg/l	0.000	0.390	0.06623	0.09149
F mg/l	0.002	0.292	0.03922	0.07140
PO4 mg/l	0.000	2.600	0.80273	0.65894
TOC mg/l				
Li mg/l	0.000	0.060	0.01927	0.01913
TURBIDY	0.0	40.0	15.500	12.083
COLOR	0.0	54.0	14.938	22.133
TDS 104°	0.010	0.130	0.07000	0.04336
TDS 180°	0.000	0.080	0.05167	0.03371
Ag mg/l	0.00000	0.03300	2.175E-03	6.031D-03
TIME hr				
Fe mg/l	0.00000	7.01960	7.932E-01	1.684D+00
Cu mg/l	0.00000	0.30000	4.619E-02	8.288D-02
Mn mg/l	0.00000	0.07420	1.276E-02	1.891D-02
Zn mg/l	0.00000	0.69000	2.321E-01	2.053D-01
Pb mg/l	0.00000	0.01500	4.151E-03	4.495D-03
Cr mg/l	0.00000	0.01607	9.841E-04	3.891D-03
Ni mg/l	0.00000	0.28900	5.996E-02	8.936D-02
Sr mg/l				

Table(7): Descriptive Statistics for Salt Station

6- Salt Station :

During the study period, thirty nine ppt. water samples were collected and analysed for their physical and chemical properties. The descriptive statistics of the different parameters are shown in table (7).

Concentrations and Fluctuation in the Physical and Chemical Parameters .

6.1- Amount of rainfall (mm) :

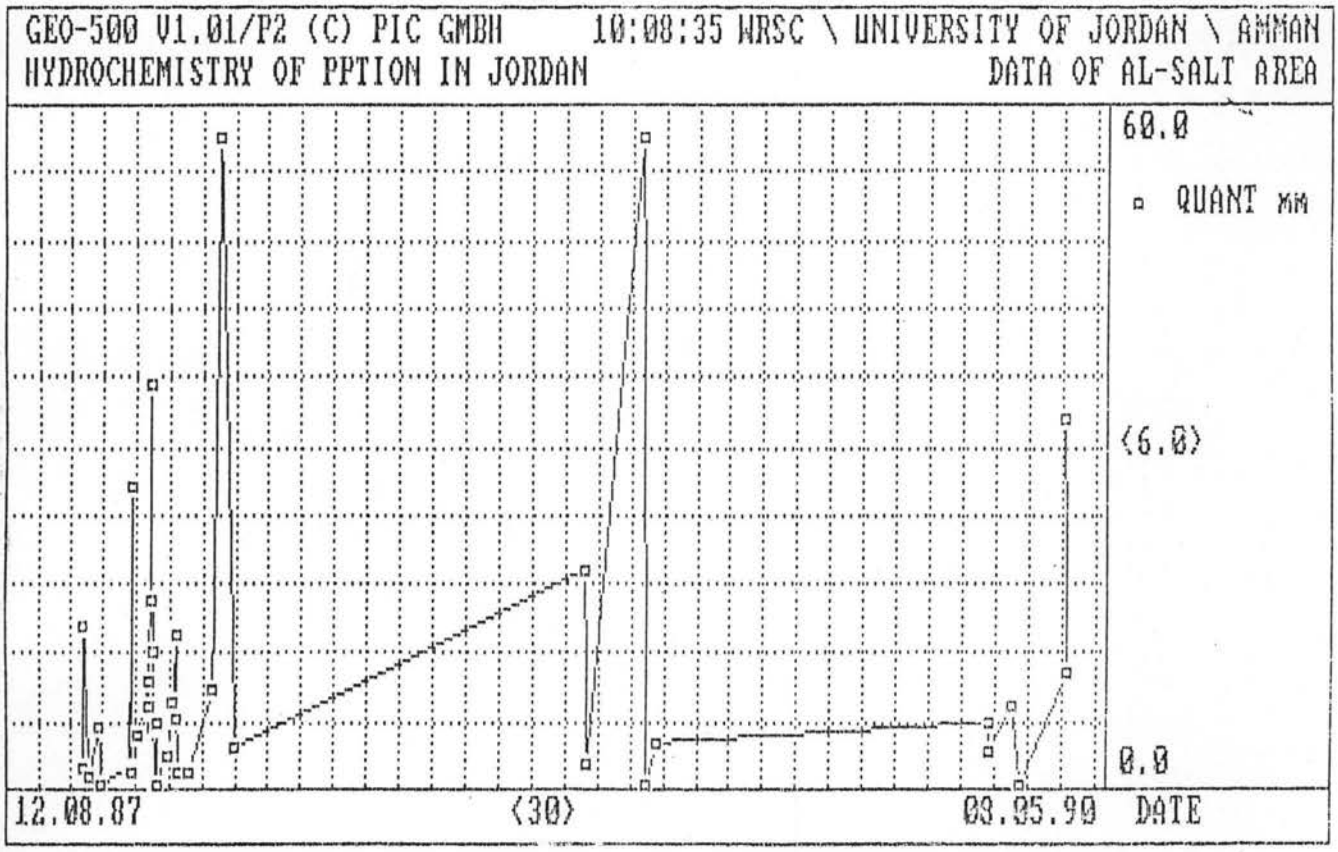
The amount of rainfall from which water samples were collected and analysed ranged from 0.2 to 57 mm. The fluctuations in the amount of ppt. are shown in figure (63). During the hydrologic years 1988/1989 and 1989/1990 only few water samples were collected and subjected to analyses and study.

6.2- pH-value.

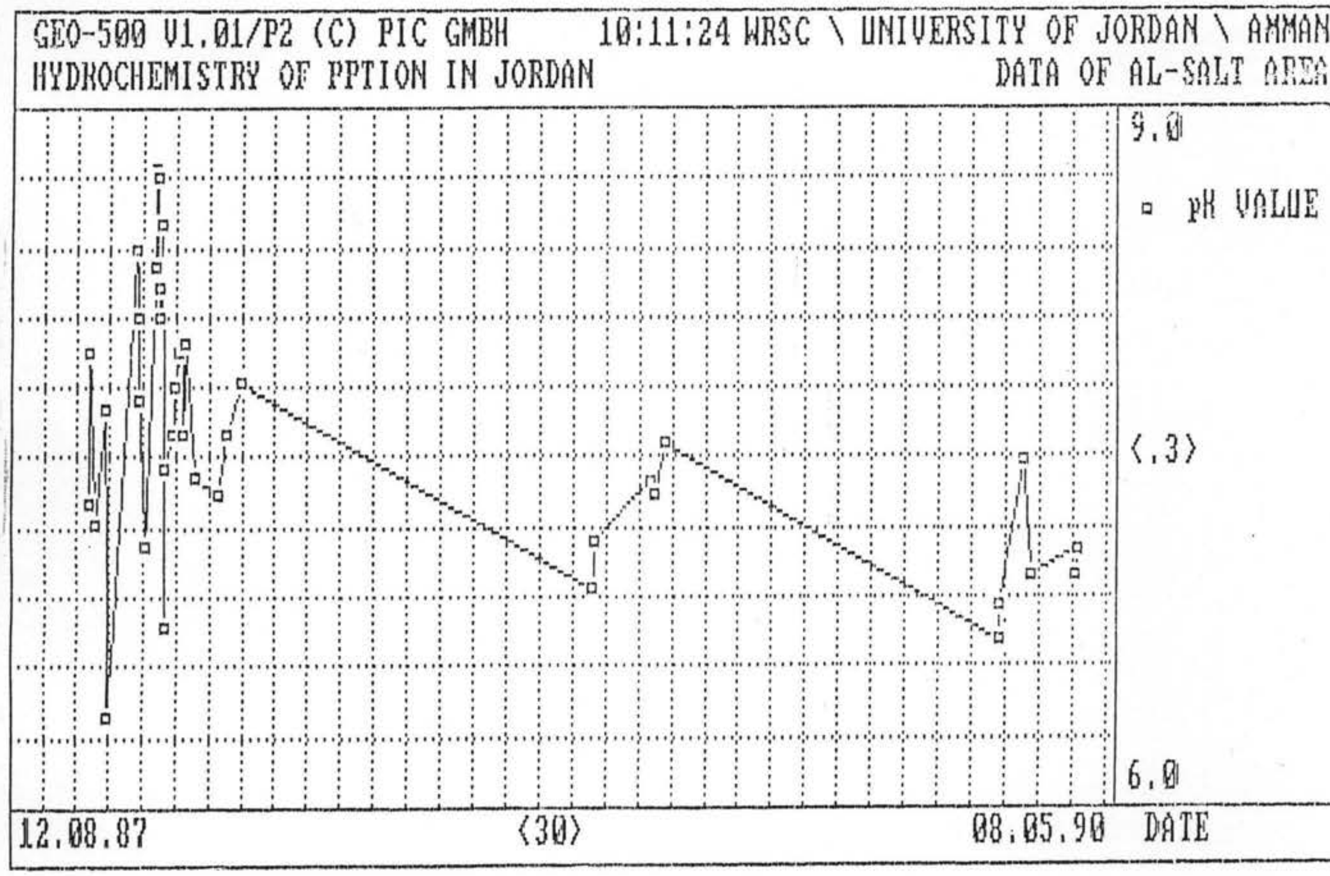
The pH-value of rain water samples ranged from 6.39 to 8.74, with an average of 7.61 $\pm$ 0.57. Figure (64), shows the fluctuations in the measured pH-value during the study period. The maximum pH-value was measured on the 22nd of December 1987, while the minimum value was recorded on the 8th of November of the same year.

6.3- Electrical conductivity

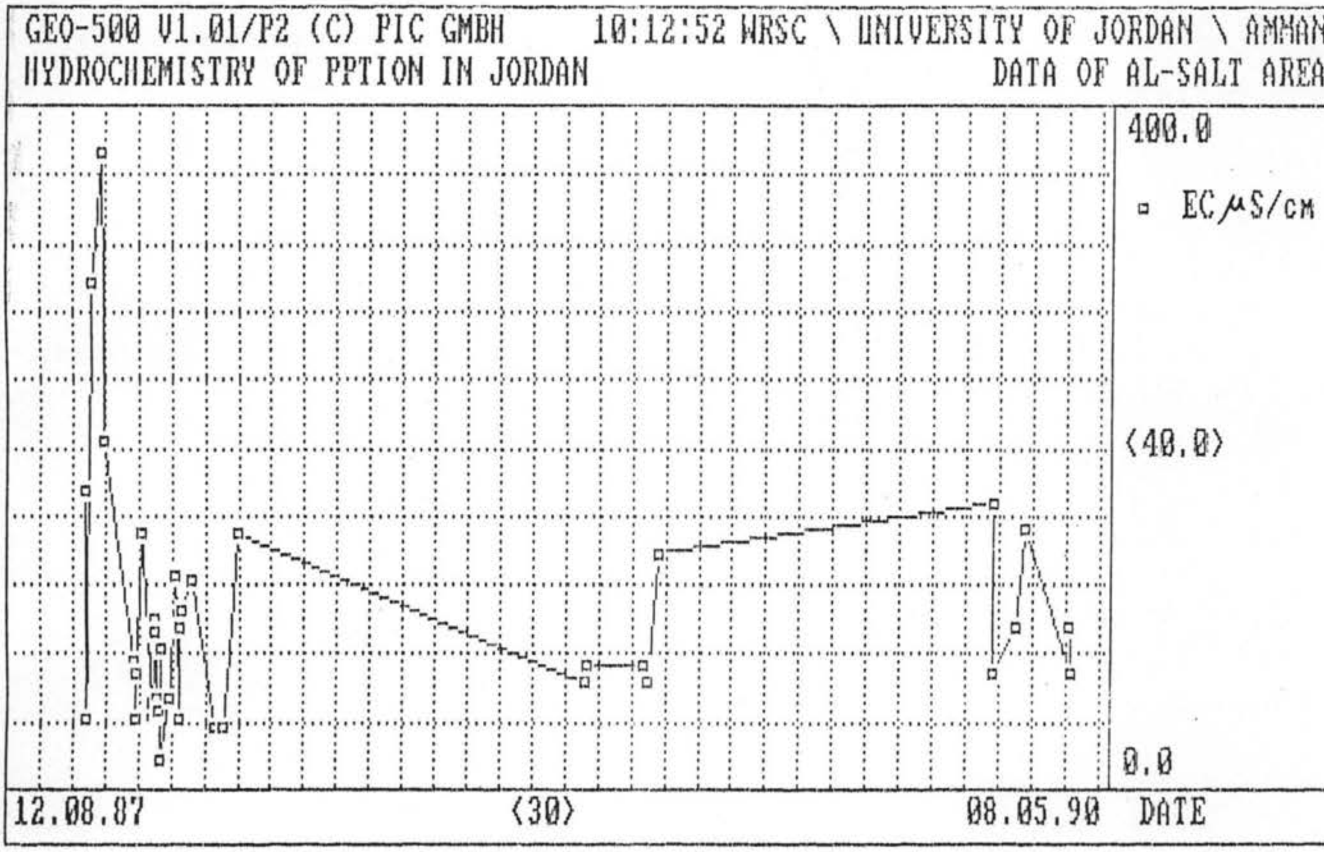
The EC of collected samples ranged from 18 to 372 μs/cm with an arth. mean of 98.7 $\pm$ 71.5 μs/cm, figure (65). The maximum recorded EC-value was on the 6th of November 1987 and the minimum was measured for rain water collected on the 30th of December 1987. Successive rainfall storms were responsible for the low measured EC.



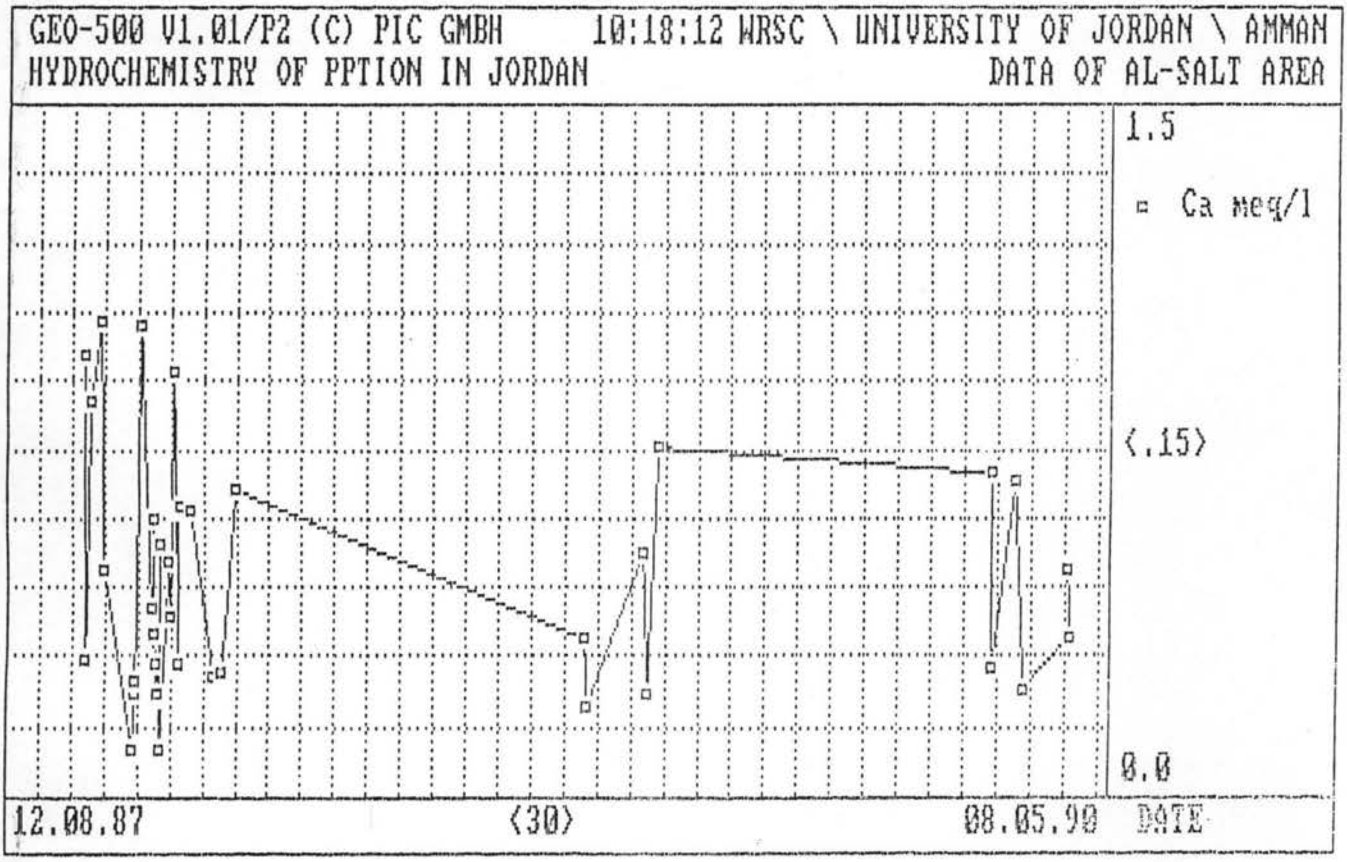
Figure(63): Fluctuations in ppt. Amounts for Salt Station



Figure(64): Fluctuations in pH for Salt Station



Figure(65): Fluctuations in EC for Salt Station



Figure(66): Fluctuations in Ca for Salt Station

6.4- Earth Alkaline Elements (Ca^{2+} & Mg^{2+})

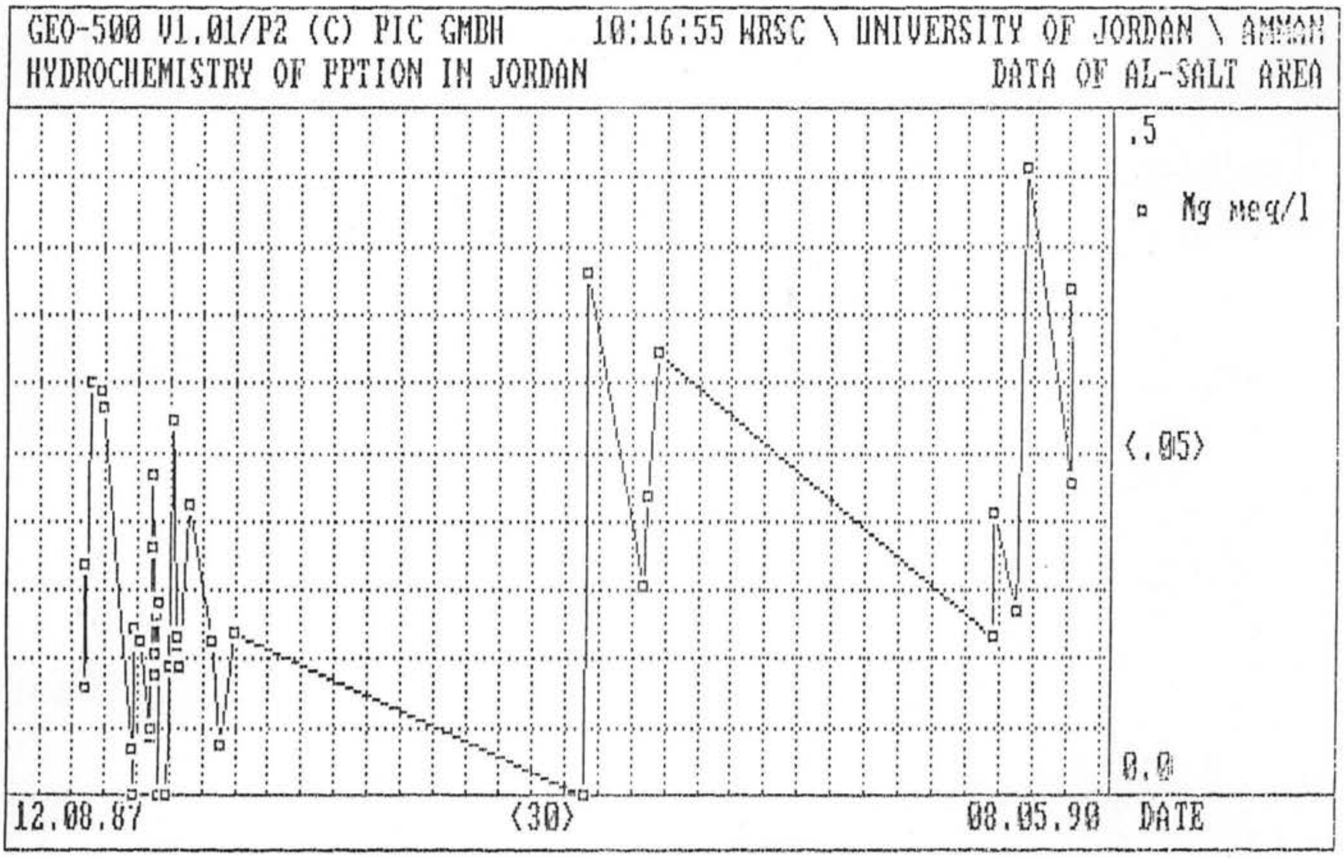
The calcium concentration represented the major cation as reaching 53 % of the total cations. Calcium content in rain water samples ranged from 0.10 to 1.03 meq/l with an arth. mean of 0.47 ± 0.26 meq/l, figure (66). The maximum Ca content was measured on the 6th of November 1987, while the minimum was recorded on the 30th of December 1987. On the other hand magnesium content in ppt. water was found to range from magnesium free water to o.46 meq/l. The arth. mean of magnesium content was 0.16 ± 0.11 meq/l. Figure (67), shows the fluctuation in the magnesium content during the study period. The maximum concentration was recorded at the beginning of the rainy season of 1988/1989.

6.5- Alkaline Elements (Na^{+} & K^{+})

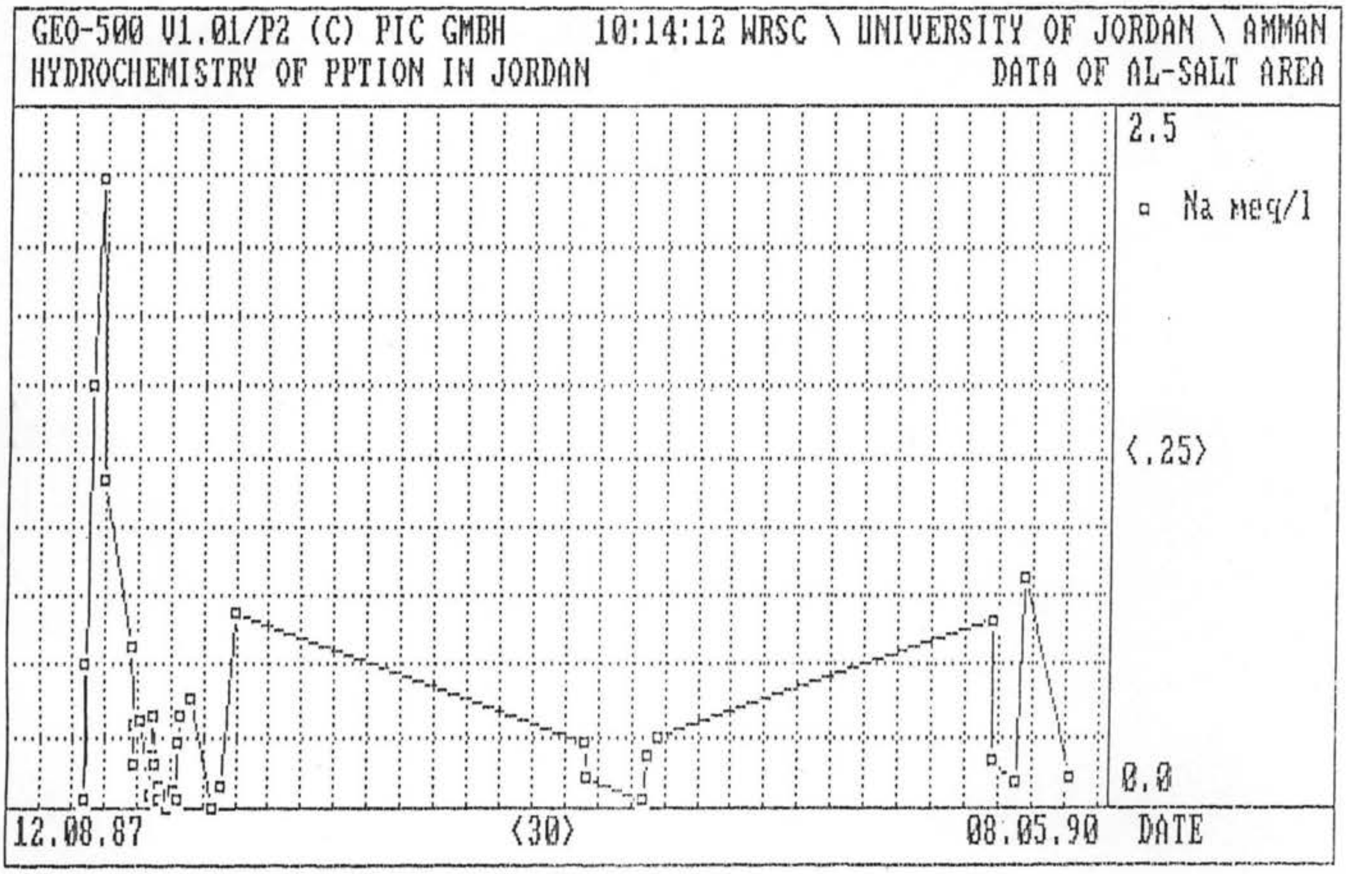
The sodium and potassium contents ranged from Na and K free waters to 2.25 and 0.32 meq/l respectively. The average values were found to be 0.32 and 0.05 meq/l for sodium and potassium respectively. The fluctuations of Na & K are shown in figures (68 and 69). The maxima for both ions were measured for rain waters collected on the 6th of November 1987.

6.6- Chloride

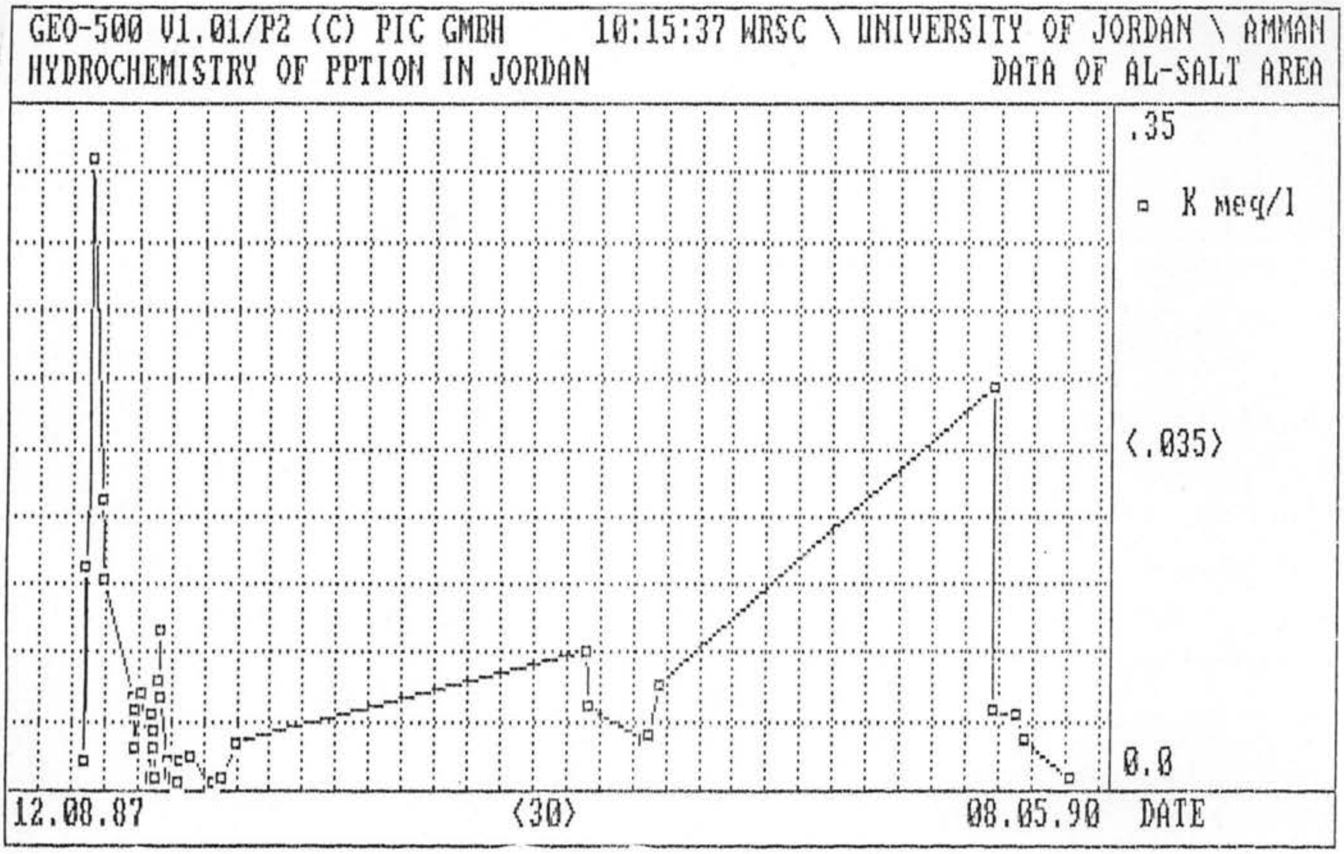
The chloride ion represent the dominant anion in the rain water collected from this station. It represented about 39 % of the total anions. The chloride contents ranged from 0.045 to 2.205 meq/l, with an average of 0.42 meq/l, figure (70). The maximum concentration was measured for ppt. water collected on the 6th of November 1987, while the minimum value was measured on



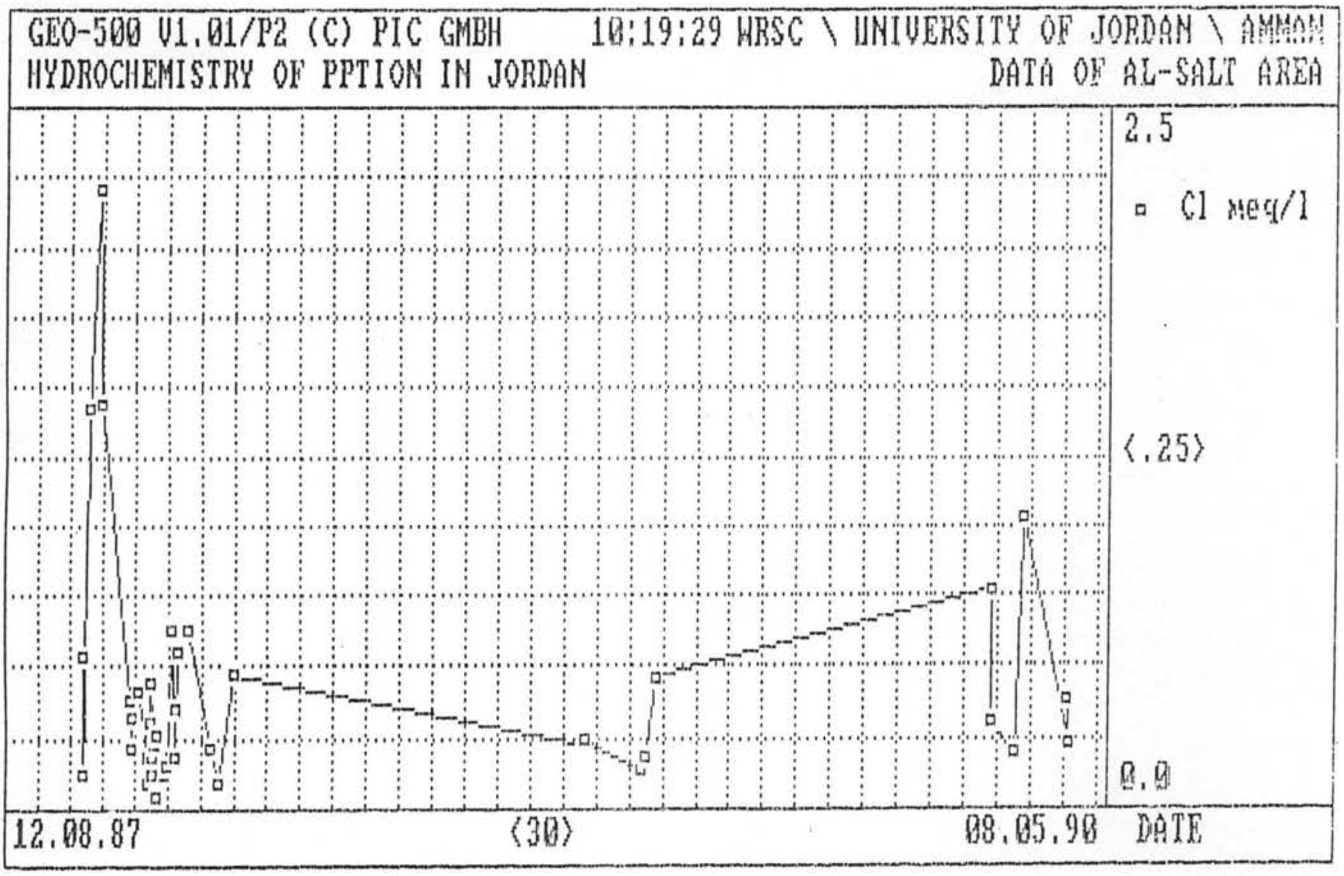
Figure(67): Fluctuations in Mg for Salt Station



Figure(68): Fluctuations in Na for Salt Station



Figure(69): Fluctuations in K for Salt Station



Figure(70): Fluctuations in Cl for Salt Station the 30th of December of the same year.

6.7- Sulfate (SO_4^{2-})

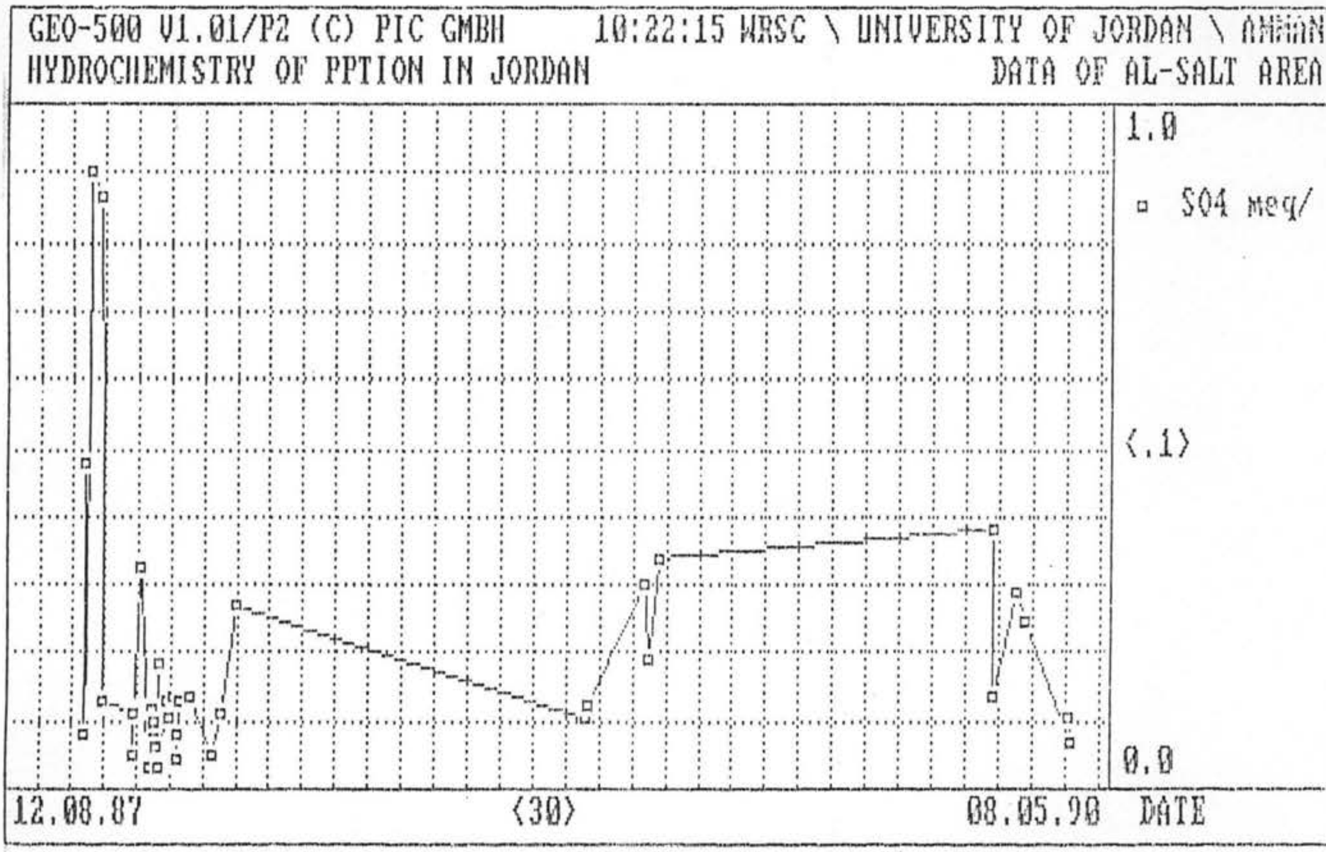
The sulfate content ranged from 0.03 to 0.90 meq/l with an average of 0.19 meq/l. Figure (71), shows the fluctuations in the sulfate concentration in the rain water samples collected during the study period. The maximum concentration was measured in rain water collected on the 29th of October 1987, while the minimum content was recorded on 21st of December 1987.

6.8- Nitrate (NO_3^-)

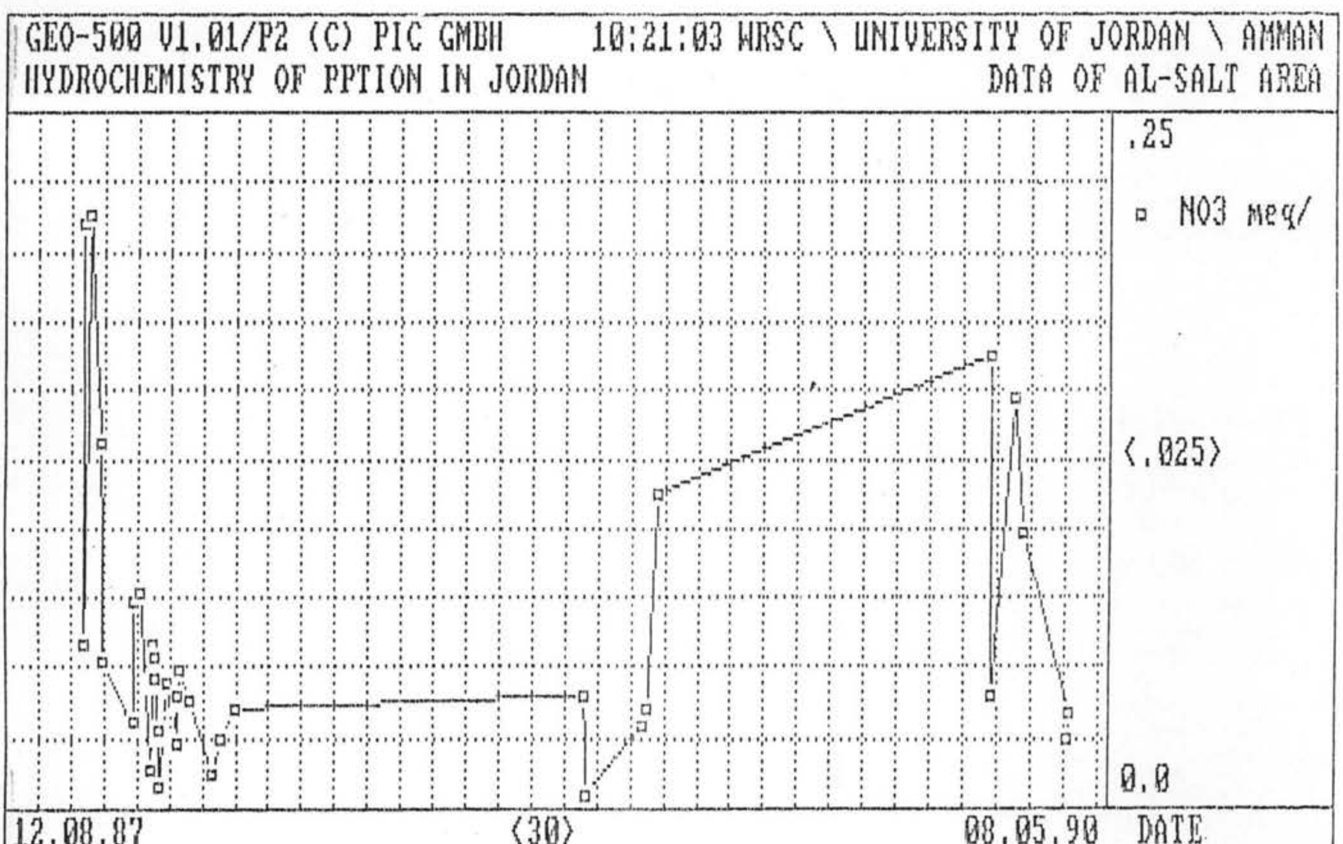
The nitrate concentrations in rain water samples were found to range between 0.004 and 0.21 meq/l with an arth. mean of 0.06 $\pm$ 0.05 meq/l, figure (72). The maximum concentration was measured in rain water samples collected on the 29th of October , while minimum value was measured on the 22nd of January 1989.

6.9- Bicarbonate (HCO_3^-)

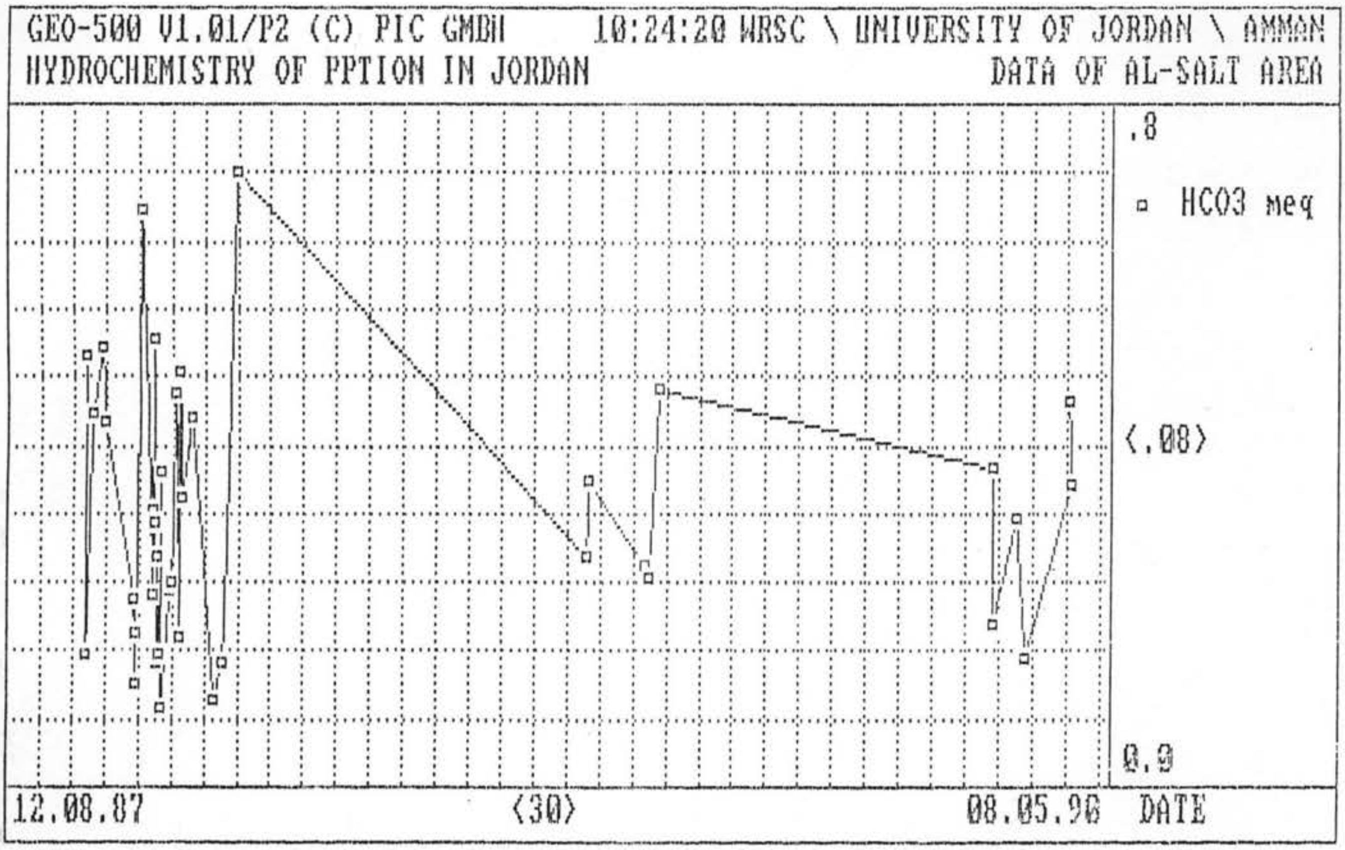
The content of bicarbonate in ppt. waters collected from Salt was found to range from 0.1 to 0.72 meq/l with an average of 0.32 $\pm$ 0.16 meq/l, figure (73). The maximum bicarbonate content was measured in rainfall water collected on the 8th of March 1988; almost at the end of the rainy season of the hydrologic year 1987/1988 when the temperature of the atmosphere started to rise up.



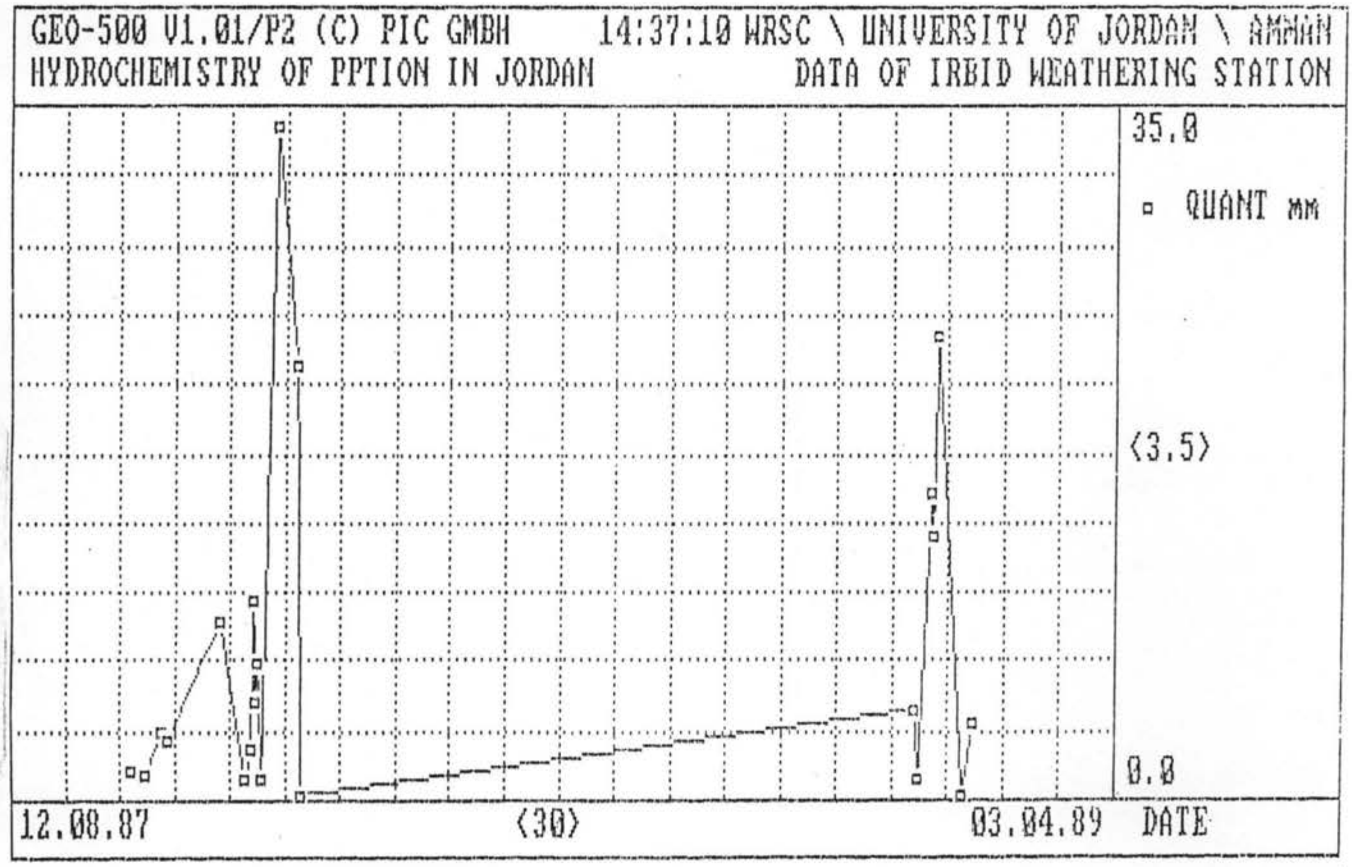
Figure(71): Fluctuations in SO_4 for Salt Station



Figure(72): Fluctuations in NO_3 for Salt Station



Figure(73): Fluctuations in HCO_3 for Salt Station



Figure(74): Fluctuations in ppt. Amounts for Irbid Weather Station

7- Irbid Station

In the northern part of Jordan two stations were installed to collect ppt. water. The first one in the center of Irbid city and the second in the metereological station at the University of Sciences and Technology. From the first station, only sixteen water samples were collected during the first year 1987/1988 while twenty five samples were collected during the hydrologic years 1987/1988 and 1988/1989 from the second station. The descriptive statistics of the analysed parameters of the two station are shown in tables (8 and 9). No major differences between the quality of ppt. in the two stations were detected. The quality of ppt. water is a function of many variables such as the origin of the storm depression, i.e. whether it comes from the north, south or west, and to the direction of the depression invading the country. The fluctuations in the analysed parameters of the weather station (station No.2) will be considered as represent active of the two stations.

Concentrations and Fluctuations of the Physical and Chemical Parameters.

7.1- Amount rainfall (mm) :

The amount of ppt. from which water samples were collected and analysed for the different parameters was found to range from 0.3 to 34 mm Figure (74). The maximum amount of ppt. was measured on the 4th of January 1988, where a composite water sample was collected.

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HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-IRBT VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32082.0	32550.0	32263.750	189.810
QUANT mm	0.8	31.8	9.431	8.734
TEMP °C..	3.8	19.8	13.087	4.815
pH VALUE	6.55	8.07	7.2006	0.3737
EC µS/cm	31.0	365.0	95.162	93.167
Na meq/l	0.006	0.538	0.17571	0.16214
K meq/l	0.005	0.741	0.06047	0.18208
Mg meq/l	0.000	0.920	0.18726	0.21718
Ca meq/l	0.162	2.122	0.52815	0.56975
Cl meq/l	0.067	0.619	0.22882	0.14325
NO3 meq/	0.007	0.454	0.05595	0.10755
SO4 meq/	0.023	1.423	0.27290	0.43576
HCO3 meq	0.078	1.155	0.39388	0.33222
TC meq/l	0.310	3.650	0.95163	0.93167
TA meq/l	0.310	3.650	0.95162	0.93167
I mg/l	0.008	0.032	0.01888	0.00866
Br mg/l	0.001	0.040	0.02050	0.02758
F mg/l	0.009	0.092	0.04283	0.03686
PO4 mg/l	1.170	4.990	3.64500	1.74298
TOC mg/l				
Li mg/l	0.000	0.022	0.01680	0.00944
TURBIDY	0.0	6.0	2.333	2.338
COLOR	0.0	2.5	1.167	1.033
TDS 104°	0.090	0.100	0.09500	0.00707
TDS 180°	0.040	0.050	0.04500	0.00707
Ag mg/l	0.00000	0.03300	3.638E-03	9.150D-03
TIME hr				
Fe mg/l	0.00900	0.52900	2.690E-01	3.677D-01
Cu mg/l	0.00000	0.00500	2.500E-03	3.536D-03
Mn mg/l	0.00000	0.03900	1.950E-02	2.758D-02
Zn mg/l				
Pb mg/l	0.00120	0.00140	1.300E-03	1.414D-04
Cr mg/l	0.00000	0.00370	1.850E-03	2.616D-03
Ni mg/l	0.00000	0.00000	0.000E+00	0.000D+00

Table(8): Descriptive Statistics for Irbid Town Station

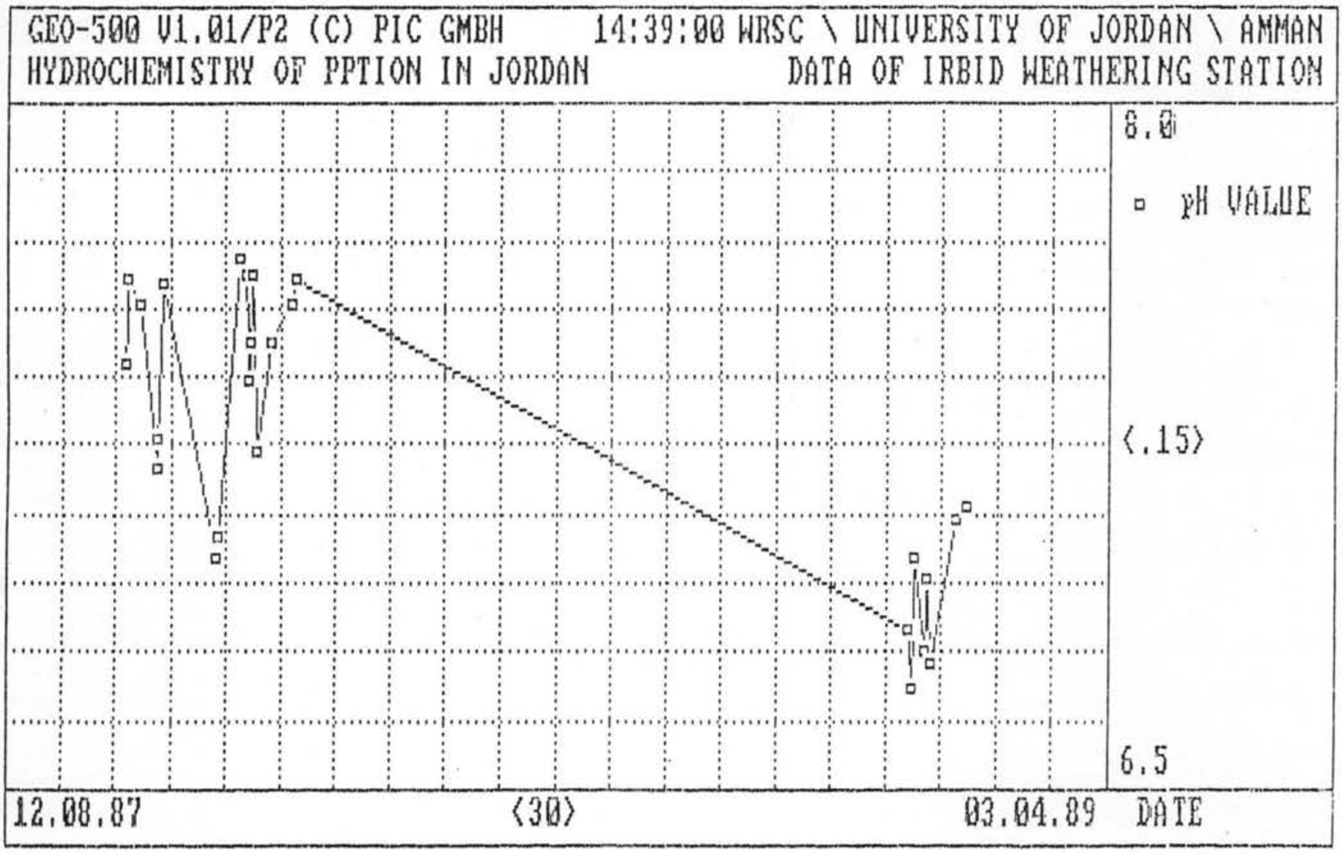
STASY V7.02/12 (C) PIC GMBH WRSC UNIV.JORDAN 10.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-IRBW VOM 15.07.15

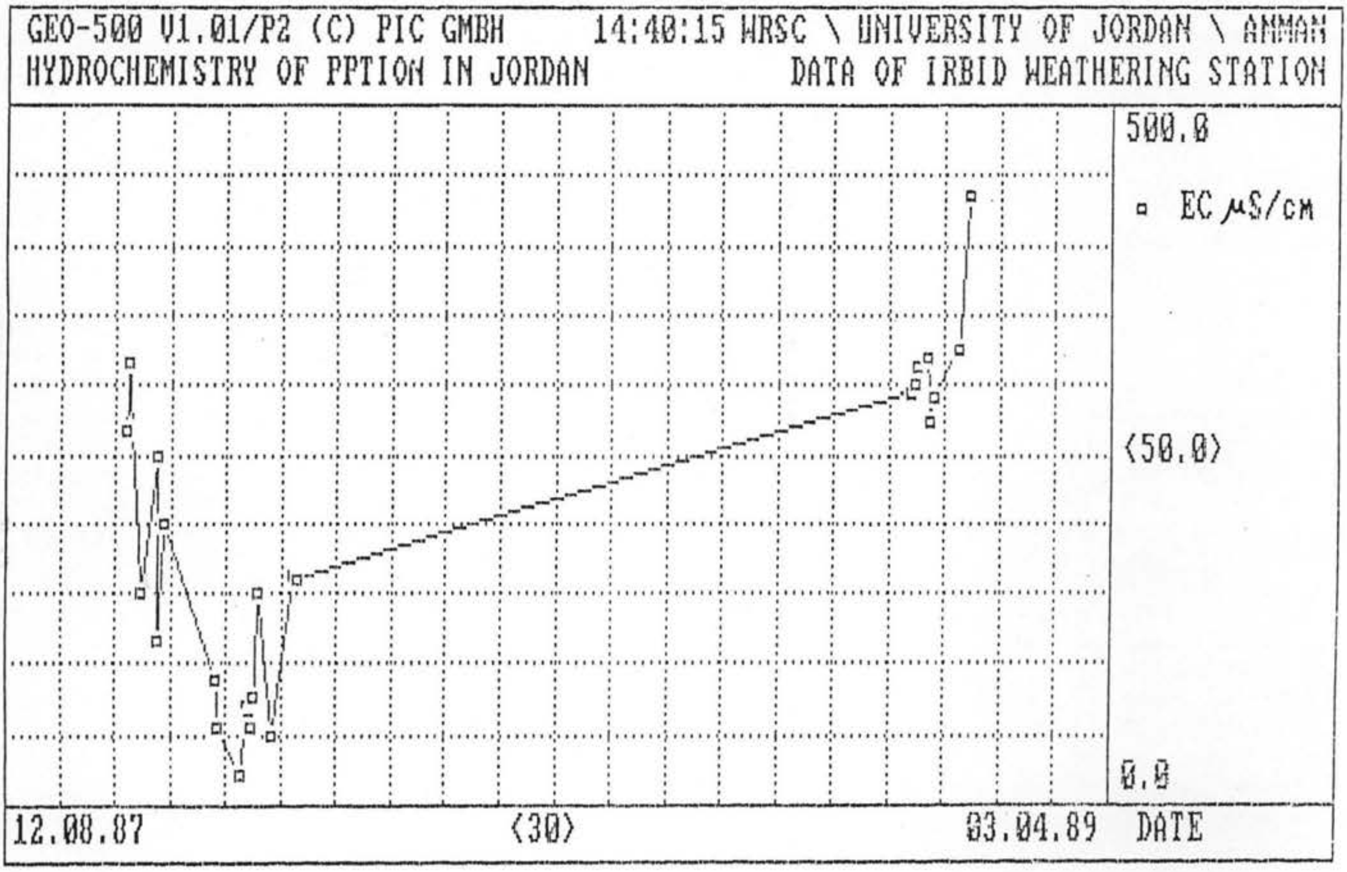
2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32066.0	32523.0	32238.680	187.316
QUANT mm	0.3	34.0	7.354	8.662
TEMP °C	12.3	14.7	13.750	1.133
pH VALUE	6.72	7.66	7.2684	0.3105
EC µS/cm	23.0	436.0	192.244	116.349
Na meq/l	0.002	1.320	0.47806	0.42876
K meq/l	0.004	0.145	0.03107	0.03272
Mg meq/l	0.000	0.549	0.24883	0.16724
Ca meq/l	0.070	3.618	1.16446	0.78655
Cl meq/l	0.016	1.603	0.53973	0.40965
NO3 meq/	0.014	0.229	0.06776	0.05024
SO4 meq/	0.028	2.251	0.61734	0.54536
HCO3 meq	0.013	1.465	0.69761	0.43223
TC meq/l	0.230	4.360	1.92244	1.16349
TA meq/l	0.230	4.360	1.92244	1.16349
I mg/l	0.000	0.230	0.03838	0.07789
Br mg/l	0.000	0.880	0.15722	0.27500
F mg/l	0.000	0.065	0.01840	0.02693
PO4 mg/l	0.000	0.360	0.26100	0.11456
TOC mg/l				
Li mg/l	0.000	0.032	0.02511	0.01059
TURBIDY	0.0	6.0	4.333	1.871
COLOR	0.0	4.0	2.167	1.118
TDS 104°	0.000	0.040	0.02333	0.01323
TDS 180°	0.000	0.010	0.00111	0.00333
Ag mg/l	0.00000	0.00530	8.875E-04	1.334D-03
TIME hr				
Fe mg/l	0.00000	0.03710	1.860E-02	1.517D-02
Cu mg/l	0.00000	0.00160	4.000E-04	8.000D-04
Mn mg/l	0.00000	0.00091	3.600E-04	4.437D-04
Zn mg/l	0.00000	0.12790	4.235E-02	5.902D-02
Pb mg/l	0.00000	0.00350	8.750E-04	1.750D-03

Table(9): Descriptive Statistics for Irbid Weather Station



Figure(75): Fluctuations in pH for Irbid Weather Station



Figure(76): Fluctuations in EC for Irbid Weather Station

7.2- pH-value :

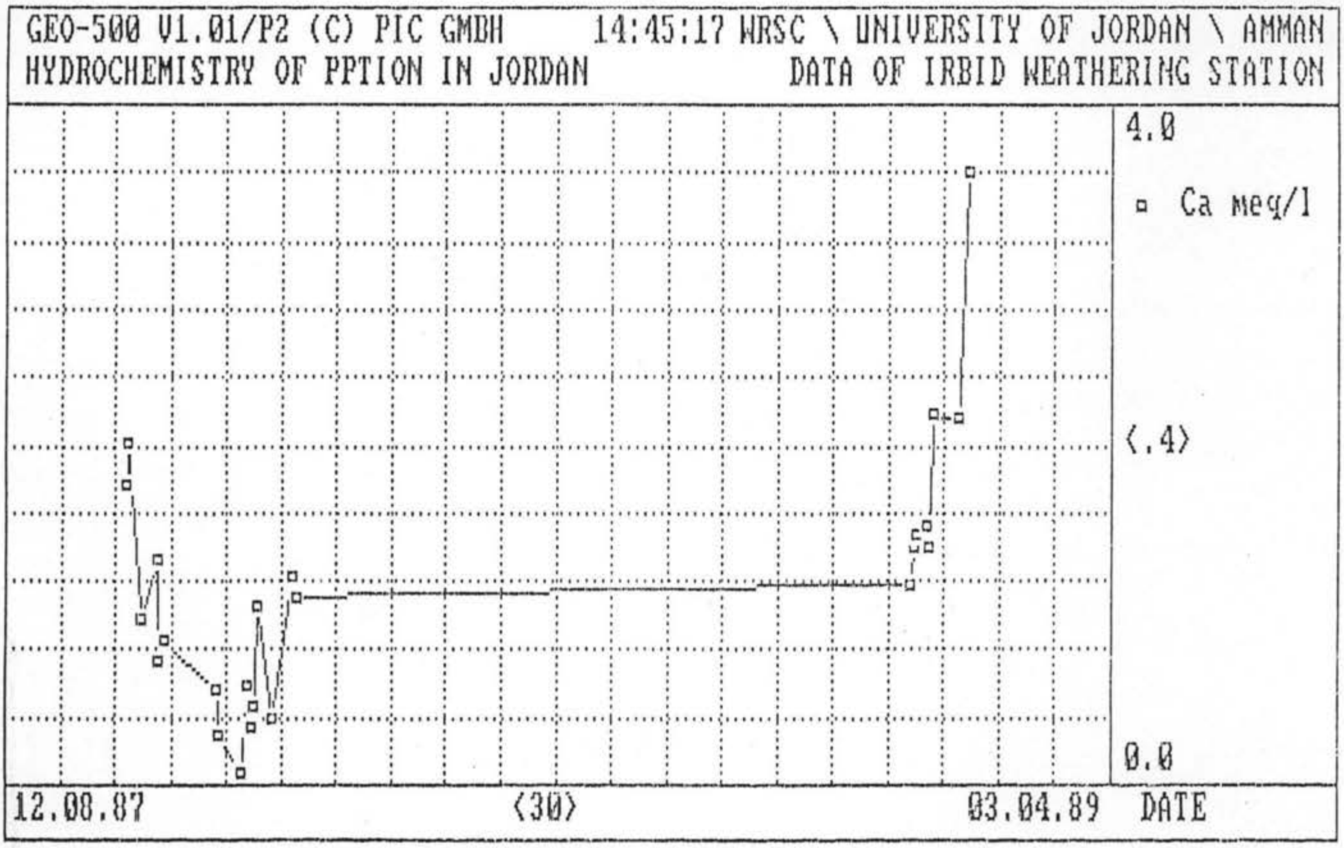
The pH-value of rain water samples collected from this station ranged from 6.72 to 7.66, with an arth. mean of 7.27 $\pm$ 0.31. Figure (75) shows the fluctuation of the measured pH-values during the study period. Generally, the pH-value of rain water collected during the hydrologic year 1988/1989 were lower than that of the hydrologic year 1987/1988. The minimum value was recorded on the 18th of December 1988, while the maximum was recorded on the 18th of December 1987.

7.3- Electrical conductivity (Ec μs/cm at 25 C^o)

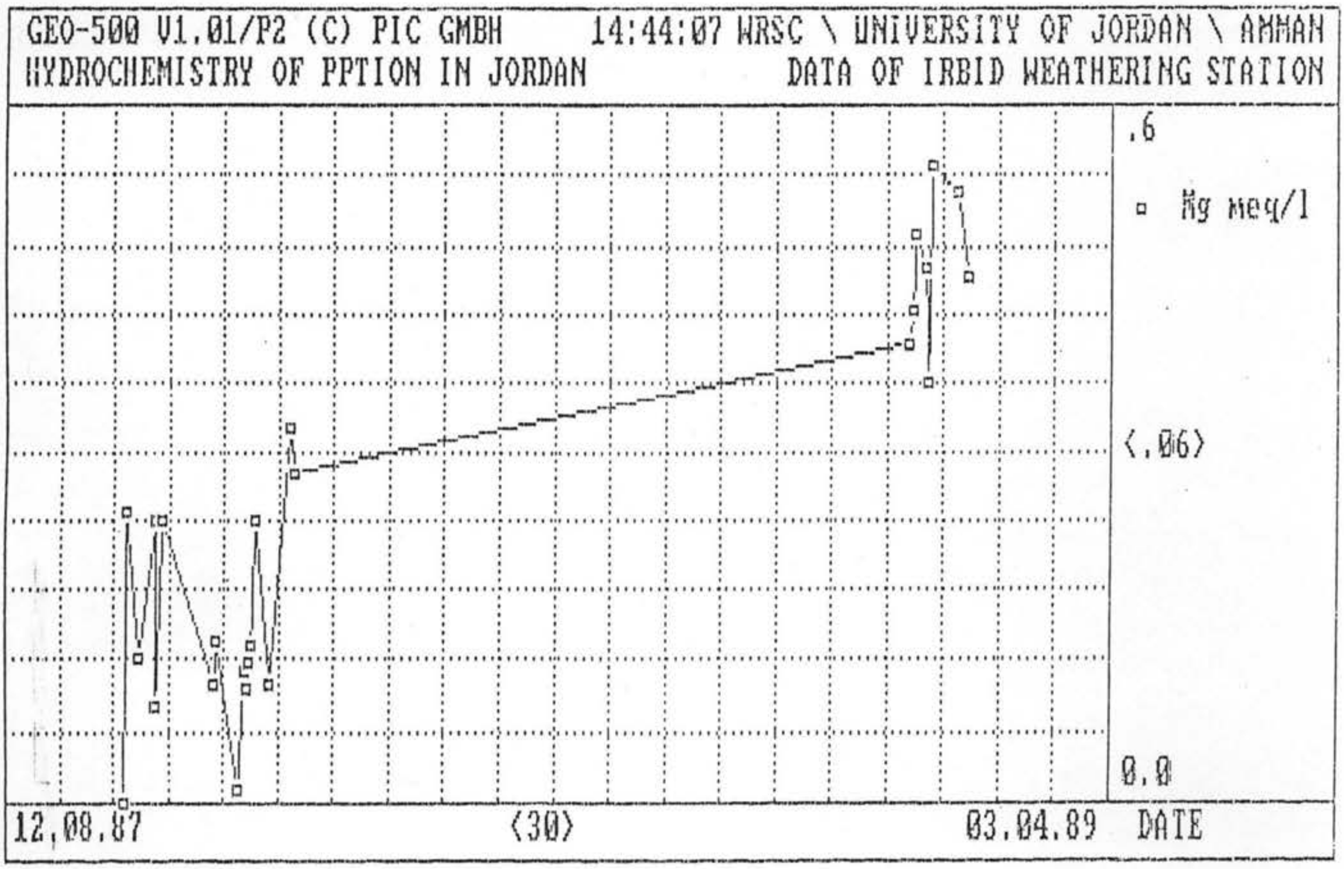
The EC ranged from 23 to 436 μs/cm with an average of 192 $\pm$ 116 μs/cm, figure (76). The maximum EC of the hydrologic year 1987/1988 was recorded at the beginning of the rainy season after that the EC of rain water tended to decrease and reached a minimum on the 18th of December, 1987. The maximum EC value during the study period was recorded on the 16th of January 1989. Generally, the EC values of ppt. water samples collected during the hydrologic year 1988/1989 were higher than those of the previous hydrologic year.

7.4- Earth Alkaline Elements (Ca^{2+} & Mg^{2+})

The calcium content of rain water collected from this station represented the dominant cation. Its concentration ranged from 0.07 to 3.62 meq/l, with an arth. mean of 1.16 $\pm$ 0.79 meq/l, figure (77). The minimum calcium content was measured on the 18th of December 1987, while the maximum recorded value was on the 16th of January 1989. The magnesium content ranged from magnesium free waters to 0.55 meq/l with an average



Figure(77): Fluctuations in Ca for Irbid Weather Station



Figure(78): Fluctuations in Mg for Irbid Weather Station of 0.25 ± 0.17 meq/l, figure (78). The maximum content was measured in rain water sample collected on the 28th of December 1989. While minimum was measured on the 18th of December 1987.

7.1.5 Alkaline Elements (Na^+ & K^+)

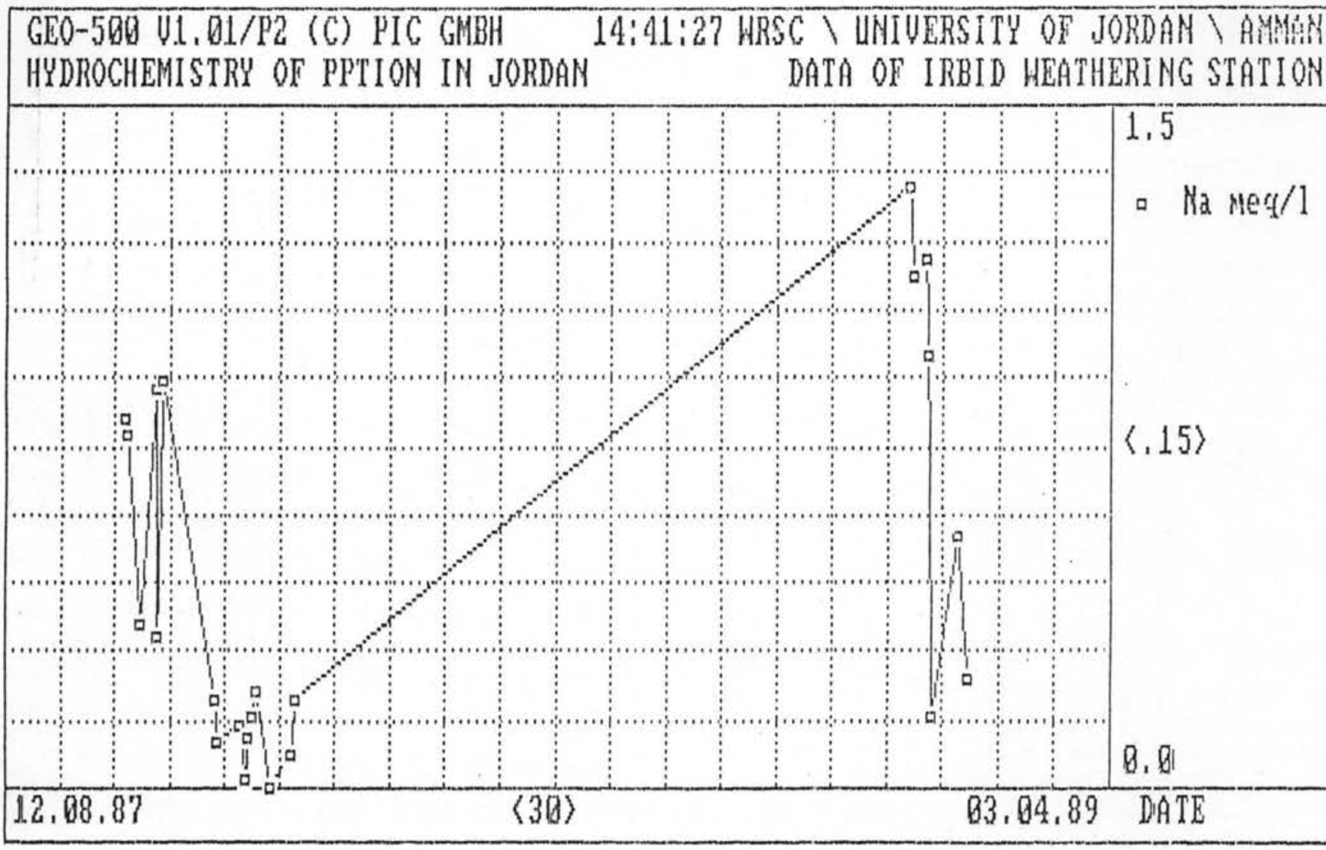
The alkaline elements in rain water samples collected from Irbid represented about 25 % of the total cations. Figures (79 and 80) show the fluctuations of sodium and potassium ions concentrations during the study period. The sodium content ranged from almost sodium free rain water to 1.32 meq/l, with an average of 0.48 ± 0.43 meq/l. The maximum Na-content was measured on the 15th of December 1988, while the minimum value was recorded on the 4th of January 1988, when successive cold depressions affected Jordan. The maximum K-content was recorded in ppt. water collected on the 18th of October 1987, at the beginning of the rainy season, while minimum K-concentration was measured in rain water samples collected on the 4th of January 1988.

7.6- Chloride (Cl^-)

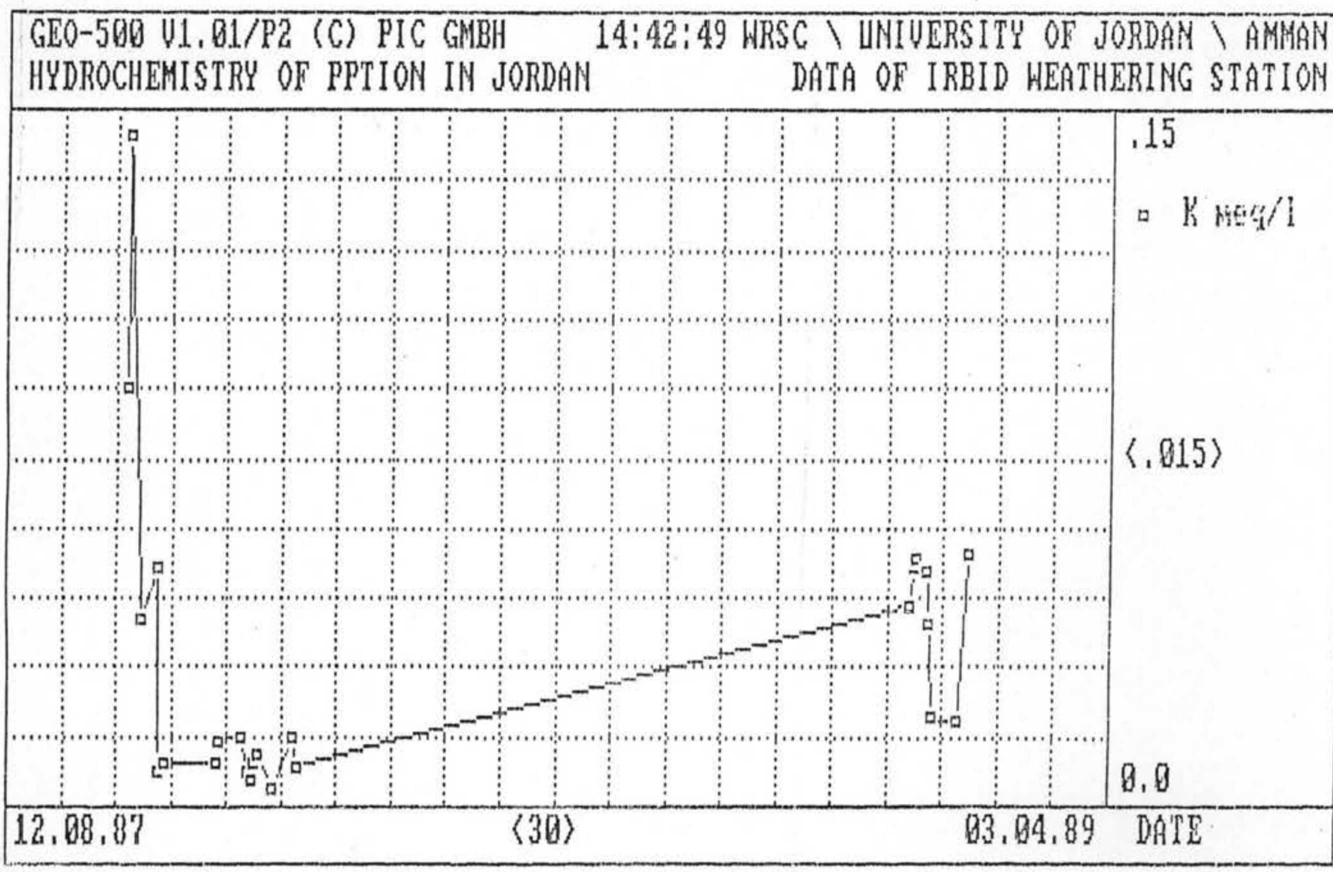
The chloride content ranged from 0.016 to 1.603 meq/l. The arth. mean was found to be 0.540 ± 0.41 meq/l. The maximum chloride content was measured on the 25th of December 1988 and the minimum value was recorded in ppt. sample collected on the 18th of December 1987 , figure (81).

7.7- Sulfate (SO_4^{2-})

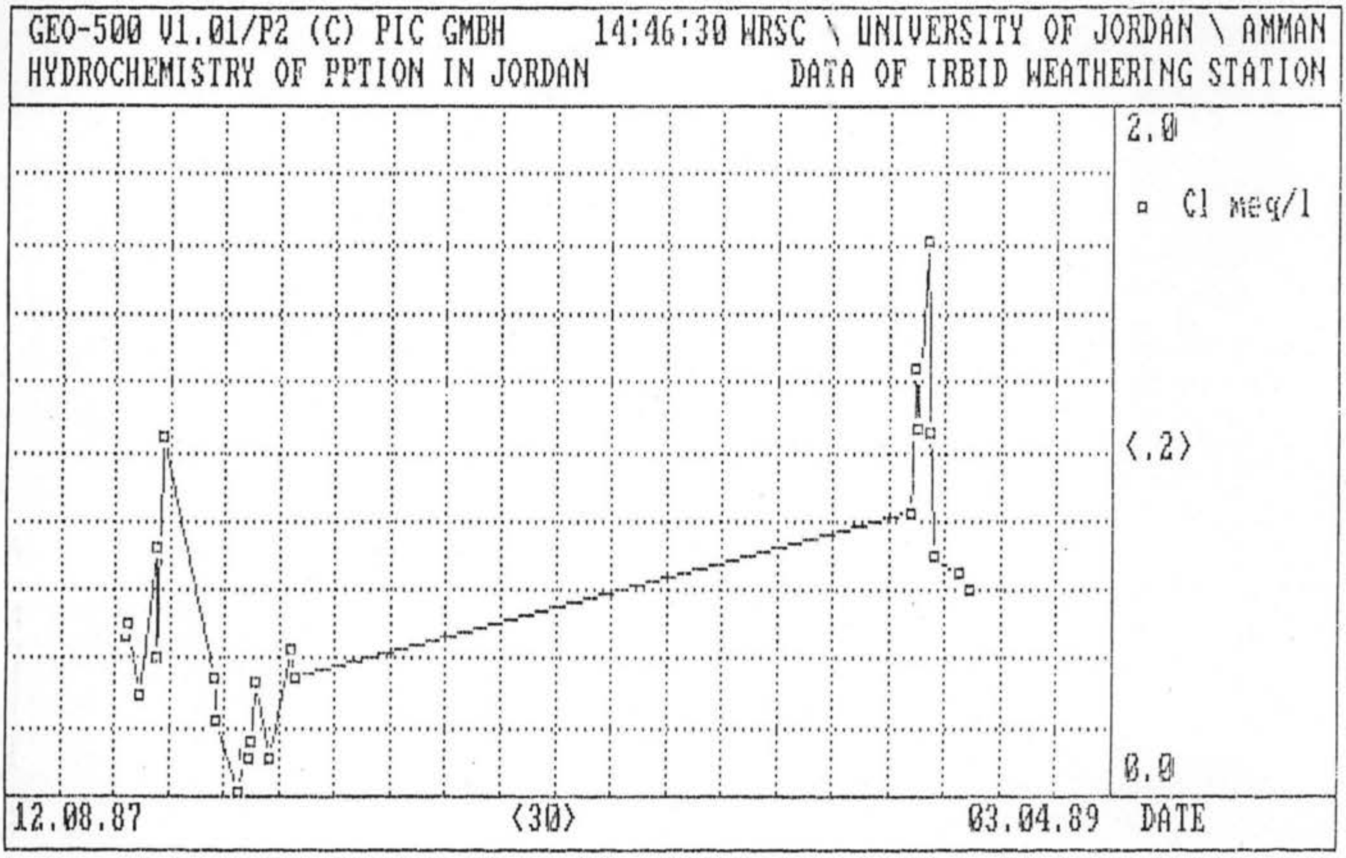
The fluctuation of sulfate contents in rain water samples is represented in figure (82). The sulfate content was found to



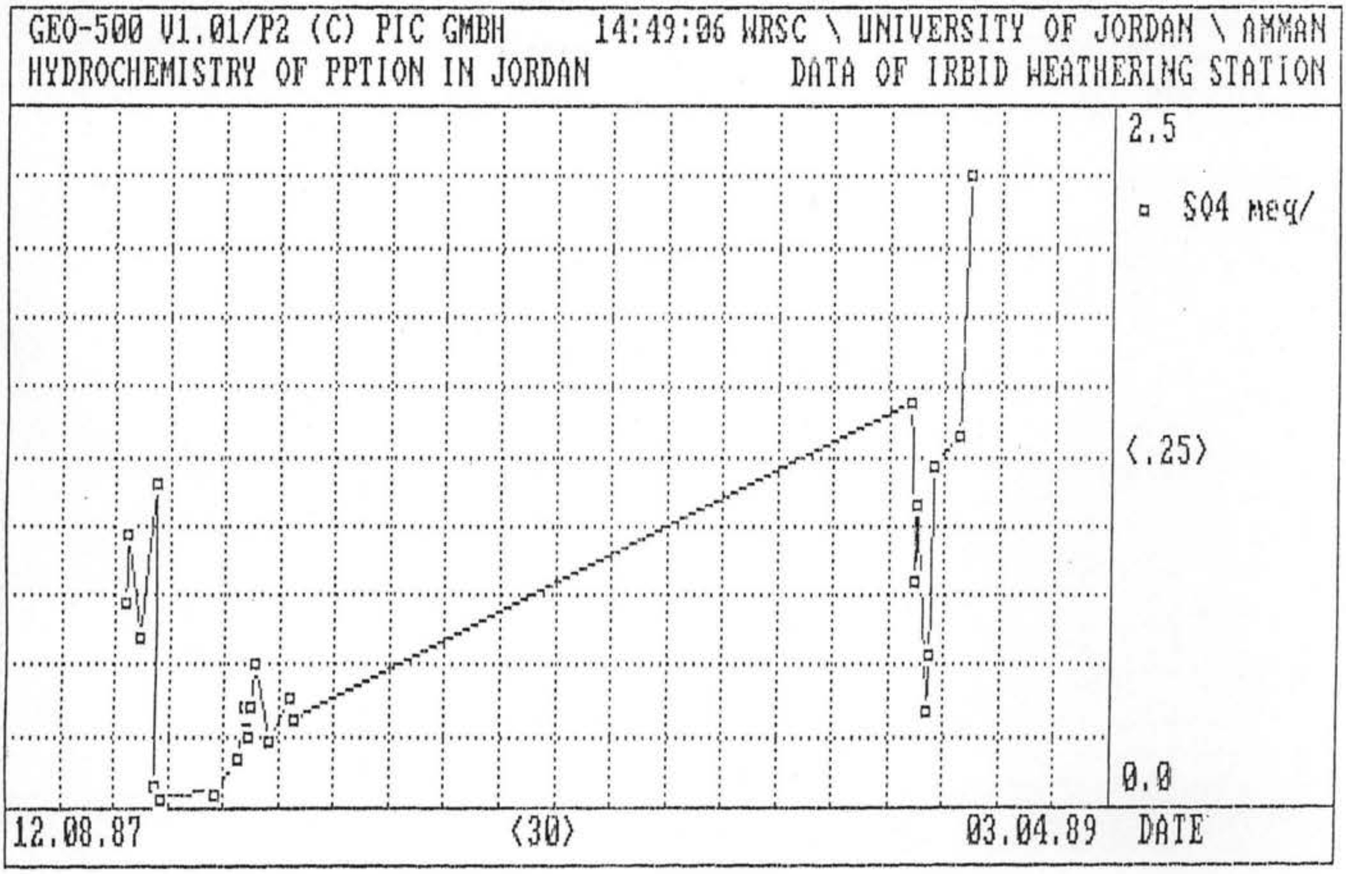
Figure(79): Fluctuations in Na for Irbid Weather Station



Figure(80): Fluctuations in K for Irbid Weather Station



Figure(81): Fluctuations in Cl for Irbid Weather Station



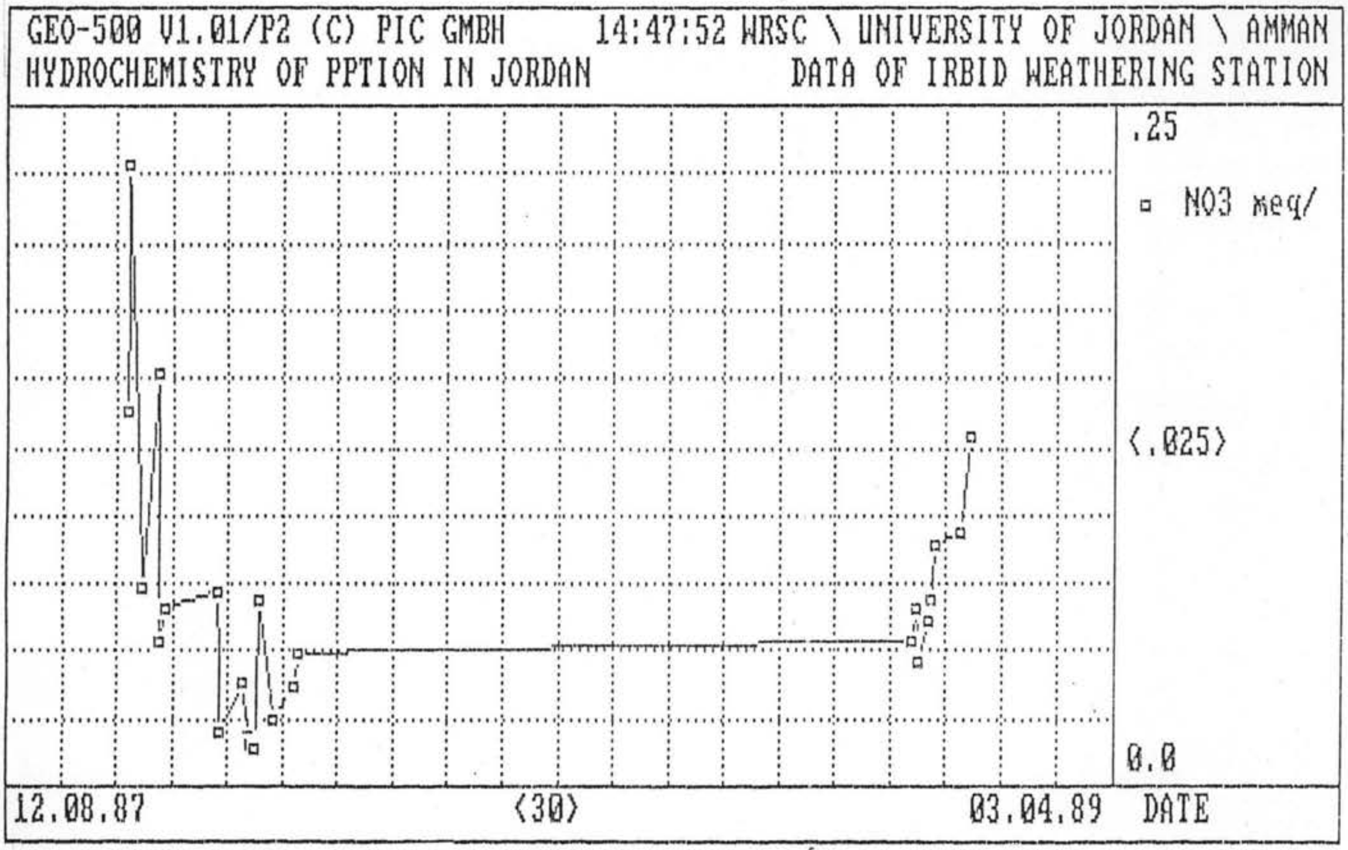
Figure(82): Fluctuations in SO_4 for Irbid Weather Station range from 0.028 to 2.251 meq/l, with an arth. mean of 0.62 ± 0.55 meq/l. The maximum recorded concentration of sulfate was found in ppt. water collected on the 16th of January 1989, and the minimum value was measured on the 6th of November 1987, when heavy cold and warm depressions affected Jordan and intensive ppt. occurred.

7.1.8 Nitrate (NO_3^-)

The nitrate content ranged from 0.014 to 0.229 meq/l, with an average of 0.068 ± 0.05 meq/l, figure (83). The maximum nitrate content was measured in rain water samples associated with intensive thunderstorms in north Jordan on the 18th of October 1987. The minimum nitrate content was recorded in the same hydrologic year 1987/1988 where successive depressions affected Jordan on the 22nd of December 1987.

7.9- Bicarbonate (HCO_3^-)

The bicarbonate fluctuations are presented in figure (84). The bicarbonate content during the study period was found to range from 0.013 to 1.465 meq/l, with an average of 0.70 ± 0.43 meq/l. The maximum value was measured on the 18th of October 1987, at the beginning of the rainy season (1987/1988) and the minimum content was recorded in the same rainy season (1987/1988) in water sample collected on the 18th of December 1987.



Figure(83): Fluctuations in NO_3 for Irbid Weather Station

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HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-IRBT VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32082.0	32550.0	32263.750	189.810
QUANT mm	0.8	31.8	9.431	8.734
TEMP °C	3.8	19.8	13.087	4.815
pH VALUE	6.55	8.07	7.2006	0.3737
EC µS/cm	31.0	365.0	95.162	93.167
Na meq/l	0.006	0.538	0.17571	0.16214
K meq/l	0.005	0.741	0.06047	0.18208
Mg meq/l	0.000	0.920	0.18726	0.21718
Ca meq/l	0.162	2.122	0.52815	0.56975
Cl meq/l	0.067	0.619	0.22882	0.14325
NO3 meq/	0.007	0.454	0.05595	0.10755
SO4 meq/	0.023	1.423	0.27290	0.43576
HCO3 meq	0.078	1.155	0.39388	0.33222
TC meq/l	0.310	3.650	0.95163	0.93167
TA meq/l	0.310	3.650	0.95162	0.93167
I mg/l	0.008	0.032	0.01888	0.00366
Br mg/l	0.001	0.040	0.02050	0.02758
F mg/l	0.009	0.092	0.04283	0.03586
PO4 mg/l	1.170	4.990	3.64500	1.74298
TOC mg/l				
Li mg/l	0.000	0.022	0.01680	0.00344
TURBIDY	0.0	6.0	2.333	2.338
COLOR	0.0	2.5	1.167	1.033
TDS 104°	0.090	0.100	0.09500	0.00707
TDS 180°	0.040	0.050	0.04500	0.00707
Ag mg/l	0.00000	0.03300	3.638E-03	9.150D-03
TIME hr				
Fe mg/l	0.00900	0.52900	2.690E-01	3.677D-01
Cu mg/l	0.00000	0.00500	2.500E-03	3.536D-03
Mn mg/l	0.00000	0.03900	1.950E-02	2.758D-02
Zn mg/l				
Pb mg/l	0.00120	0.00140	1.300E-03	1.414D-04
Cr mg/l	0.00000	0.00370	1.850E-03	2.616D-03
Ni mg/l	0.00000	0.00000	0.000E+00	0.000D+00
Sr mg/l				

Table(8): Descriptive Statistics for Irbid Town Station

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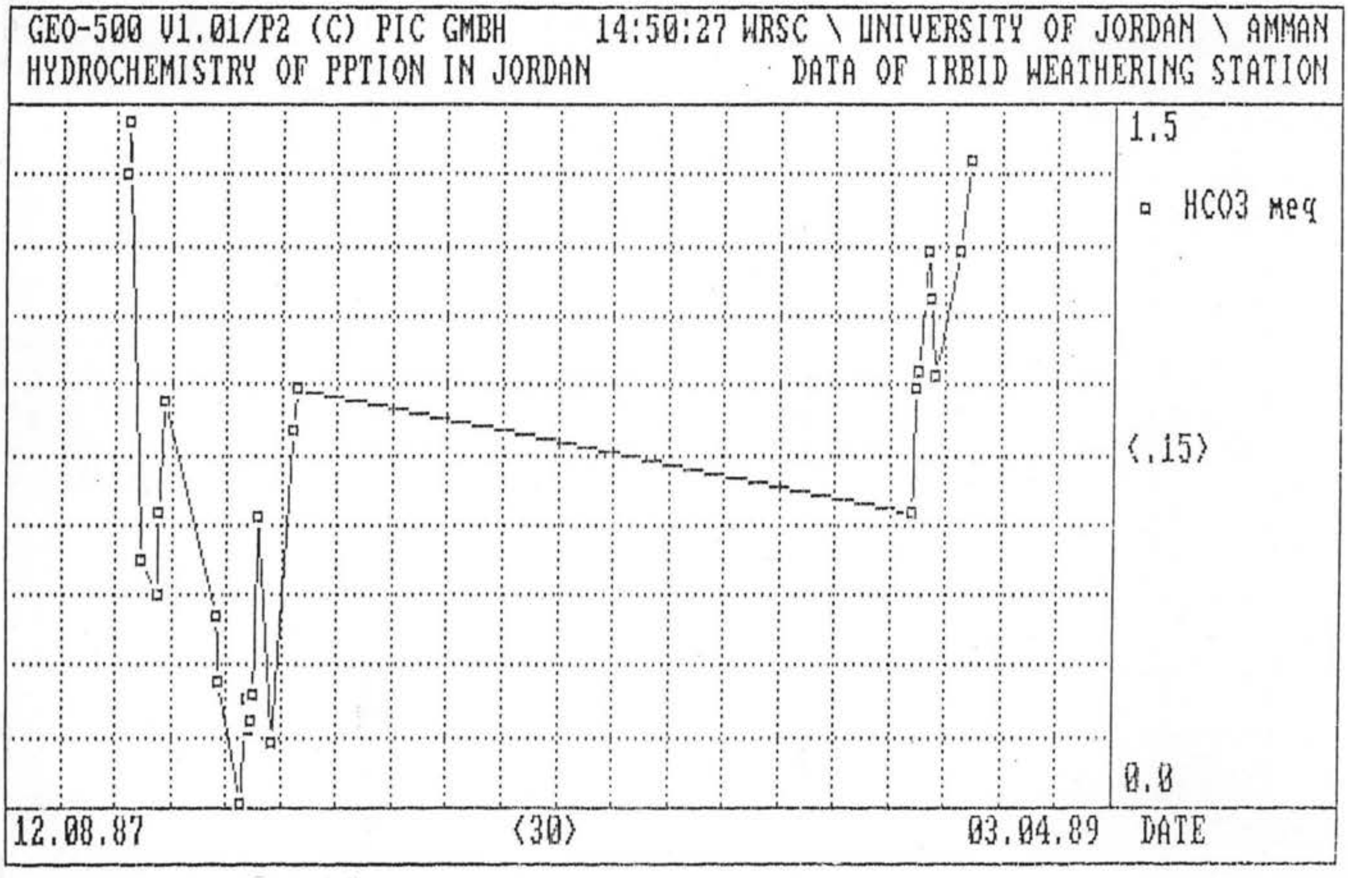
HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-IRBW VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32066.0	32523.0	32238.680	187.316
QUANT mm	0.3	34.0	7.354	8.662
TEMP °C	12.3	14.7	13.750	1.133
pH VALUE	6.72	7.66	7.2684	0.3105
EC µS/cm	23.0	436.0	192.244	116.349
Na meq/l	0.002	1.320	0.47806	0.42876
K meq/l	0.004	0.145	0.03107	0.03272
Mg meq/l	0.000	0.549	0.24883	0.16724
Ca meq/l	0.070	3.618	1.16446	0.78655
Cl meq/l	0.016	1.603	0.53973	0.40965
NO3 meq/	0.014	0.229	0.06776	0.05024
SO4 meq/	0.028	2.251	0.61734	0.54536
HCO3 meq	0.013	1.465	0.69761	0.43223
TC meq/l	0.230	4.360	1.92244	1.16349
TA meq/l	0.230	4.360	1.92244	1.16349
I mg/l	0.000	0.230	0.03838	0.07789
Br mg/l	0.000	0.880	0.15722	0.27500
F mg/l	0.000	0.065	0.01840	0.02693
PO4 mg/l	0.000	0.360	0.26100	0.11456
TOC mg/l				
Li mg/l	0.000	0.032	0.02511	0.01059
TURBIDY	0.0	6.0	4.333	1.871
COLOR	0.0	4.0	2.167	1.118
TDS 104	0.000	0.040	0.02333	0.01323
TDS 180	0.000	0.010	0.00111	0.00333
Ag mg/l	0.00000	0.00530	8.875E-04	1.334D-03
TIME hr				
Fe mg/l	0.00000	0.03710	1.860E-02	1.517D-02
Cu mg/l	0.00000	0.00160	4.000E-04	8.000D-04
Mn mg/l	0.00000	0.00091	3.600E-04	4.437D-04
Zn mg/l	0.00000	0.12790	4.235E-02	5.902D-02
Pb mg/l	0.00000	0.00350	8.750E-04	1.750D-03
Cr mg/l	0.00000	0.00000	0.000E+00	0.000D+00
Ni mg/l	0.00000	0.02100	5.250E-03	1.050D-02
Sr mg/l				

Table(9): Descriptive Statistics for Irbid Weather Station



Figure(84): Fluctuations in HCO_3 for Irbid Weather Station

8- The University of Jordan Farm Station

In order to identify the quality of rain water in the Jordan valley area, a station to collect rain water samples was installed during the study period. Twenty one samples were collected and analysed for their physical and chemical characteristics. Descriptive statistics of these parameters are shown in table (10).

Concentrations and Fluctuations of the Physical and Chemical Parameters.

8.1- Amount of rainfall in (mm).

The amount of rainfall from which water samples were collected, ranged from 0.1 to 29.2 mm, figure (85). The highest amount of precipitation was recorded at the beginning of the rainy season 1988/1989 on the 18th of November 1988 and the minimum value was measured on the 17th of January 1988.

8.2- Electrical Conductivity (EC µs/cm at 25 °C)

The electrical conductivity of rain water collected from this station was found to range from 41 to 500 µs/cm, with an average of 1.59.8 ± 133.3 µs/cm. The maximum EC-value was recorded on the 24th of December 1988 while the minimum value was measured in rain water sample collected on the 16th of February 1988, figure (86).

8.3- pH-value

The pH-value of the collected rain water samples was measured after its arrival to the WRSC-laboratories and found to range from 6.50 to 8.26. The arth, mean of the pH-value was 7.49 ± 0.42. The fluctuation in the pH-value is represented in figure

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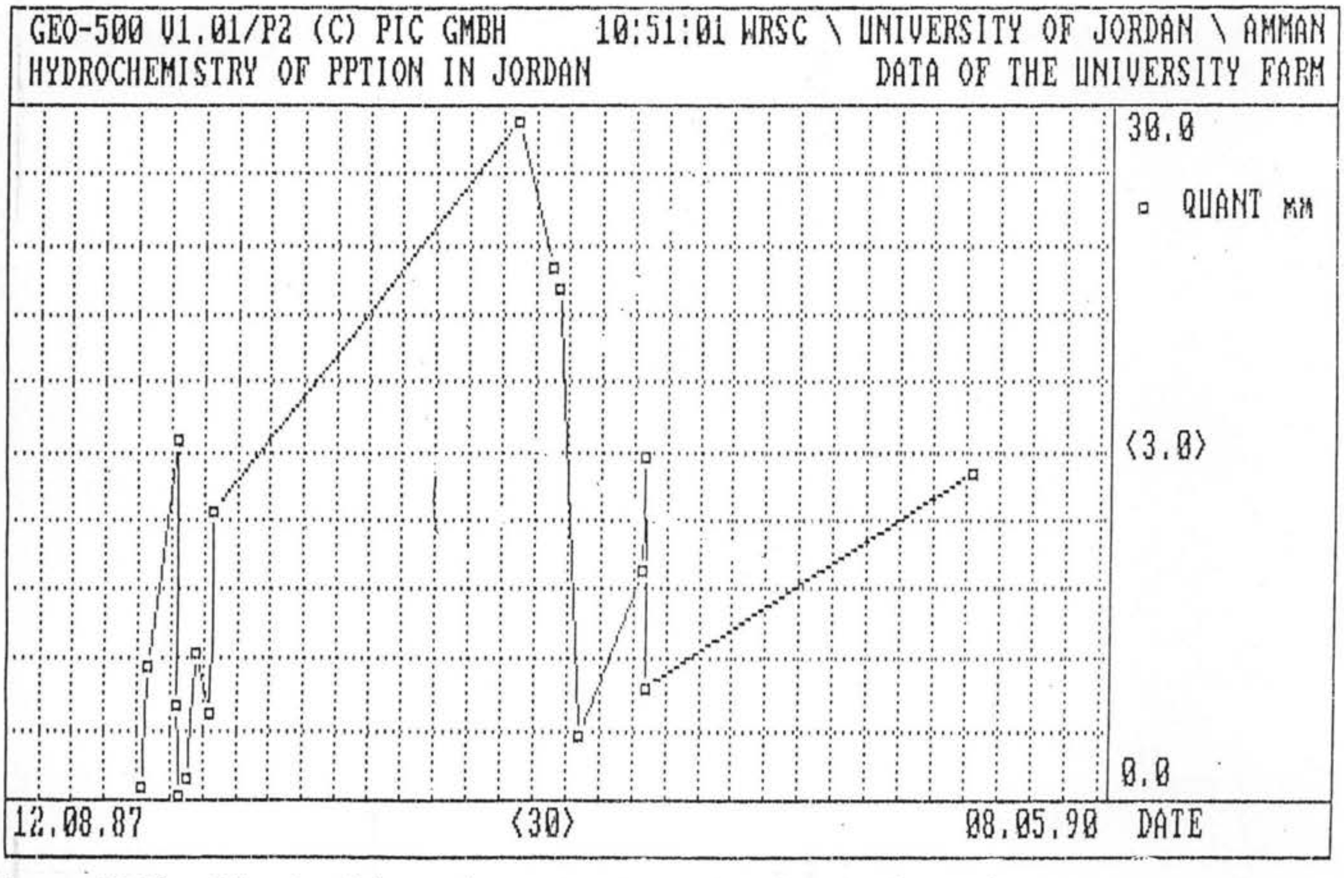
HYDROCHEMISTRY OF PPTION IN JORDAN — DATEI A:NEW-FARM VOM 15.07.15

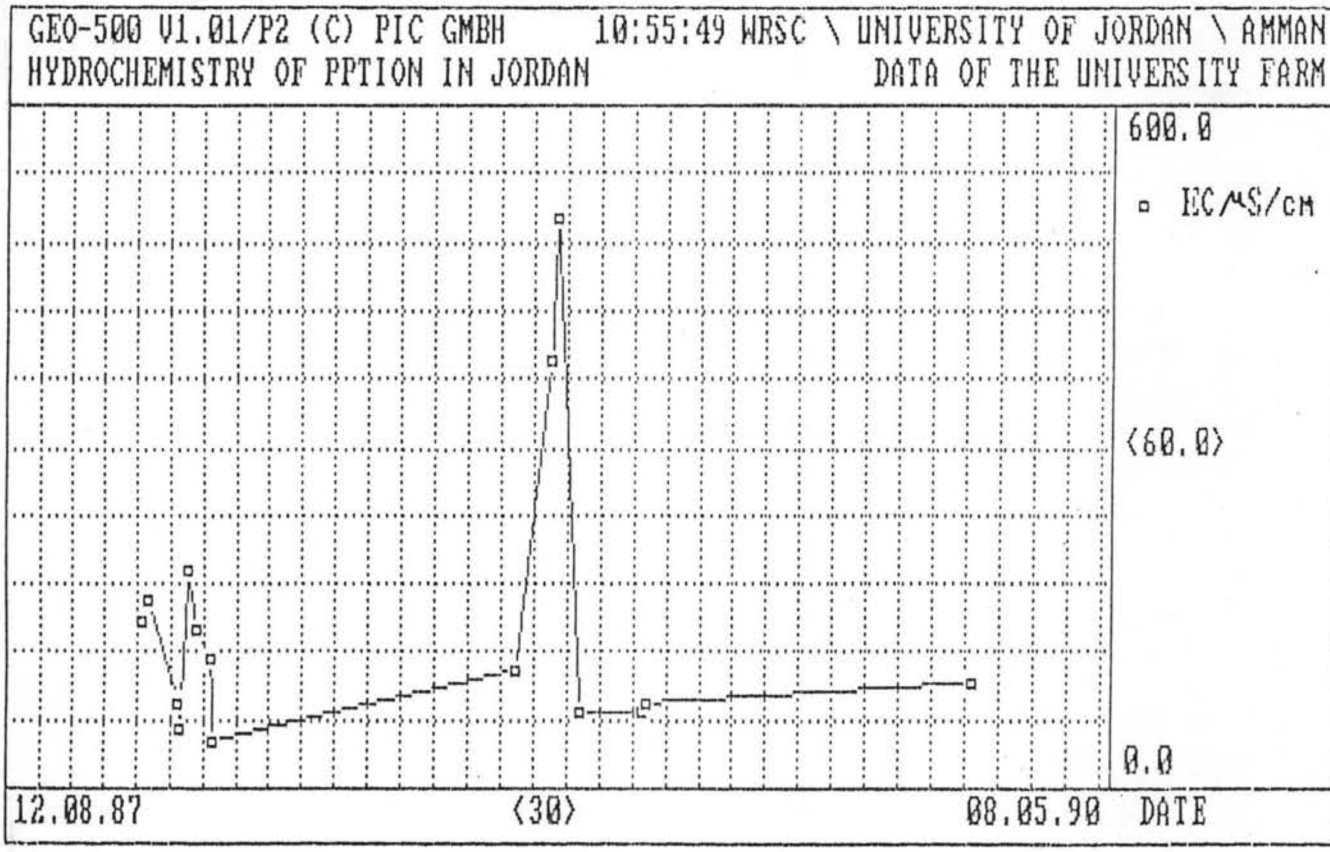
2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32125.0	32876.0	32411.953	253.348
QUANT mm	0.1	29.2	9.614	8.795
TEMP °C	11.2	30.1	18.448	4.981
pH VALUE	6.50	8.26	7.4919	0.4174
EC µS/cm	41.0	500.0	159.843	133.253
Na meq/l	0.022	1.278	0.37413	0.33775
K meq/l	0.000	0.140	0.03727	0.03840
Mg meq/l	0.000	1.825	0.30619	0.46053
Ca meq/l	0.286	2.543	0.88083	0.58823
Cl meq/l	0.095	1.554	0.47344	0.43084
NO3 meq/	0.021	0.125	0.06178	0.03001
SO4 meq/	0.081	1.008	0.35276	0.26168
HCO3meq/	0.189	2.599	0.71043	0.68535
TC meq/l	0.410	5.000	1.59845	1.33253
Ta meq/l	0.410	5.000	1.59843	1.33253
I mg/l	0.001	0.030	0.01436	0.00914
Br mg/l	0.000	2.520	0.31533	0.66471
F mg/l	0.005	0.394	0.09912	0.13164
PO4 mg/l	0.000	0.723	0.08483	0.21396
Li mg/l	0.013	0.260	0.06609	0.07533
TURBIDY	0.0	12.0	3.545	5.126
COLOR	0.0	15.0	5.167	6.021
TDS 104°	0.010	0.210	0.15200	0.08319
TDS 180°	0.000	0.200	0.09400	0.07232
Ag mg/l	0.00000	0.00616	1.022E-03	2.128D-03
Fe mg/l	0.00000	0.52900	1.625E-01	1.774D-01
Cu mg/l	0.00000	0.00213	7.114E-04	7.072D-04
Mn mg/l	0.00000	0.01500	5.504E-03	5.411D-03
Zn mg/l	0.00000	1.17000	2.622E-01	3.480D-01
Pb mg/l	0.00000	0.00840	8.329E-04	2.288D-03
Cr mg/l	0.00000	0.00280	7.807E-04	1.132D-03
Ni mg/l	0.00000	0.34000	6.207E-02	1.111D-01
Sr mg/l	0.01400	0.37000	1.491E-01	1.314D-01

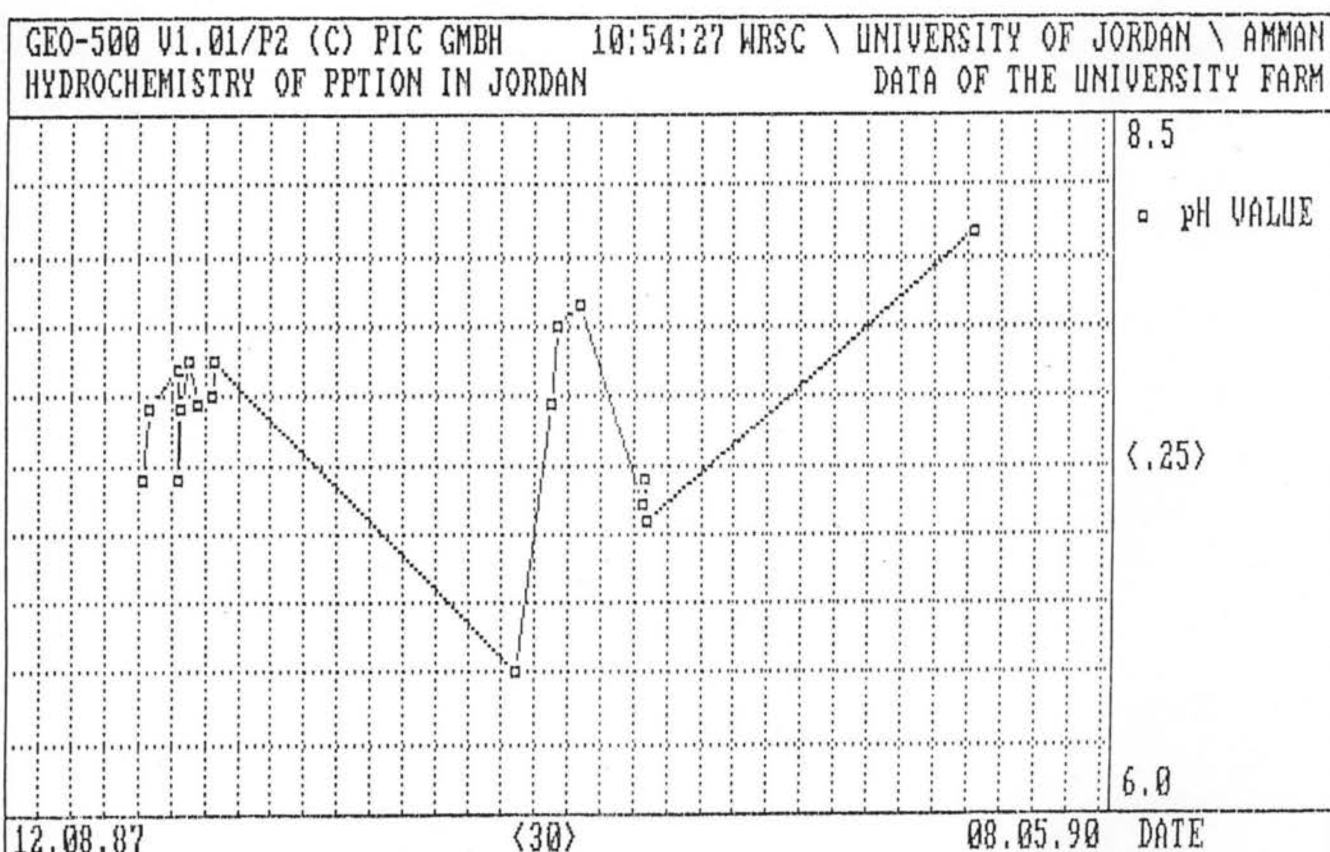
Table(10): Descriptive Statistics for University Farm Station



Figure(85): Fluctuations in ppt. Amounts for University Farm Station



Figure(86): Fluctuations in EC for University Farm Station



Figure(87): Fluctuations in pH for University Farm Station

(87). The maximum pH-value was measured on the 15th of January 1989, while the minimum value was recorded on the 18th of November 1988.

8.4- Earth alkaline elements (Ca^{2+} & Mg^{2+})

Figures (88 and 89) show the fluctuation of calcium and magnesium content in rain water samples collected during the study period. The calcium content ranged from 0.29 to 2.24 meq/l with an average of 0.88 ± 0.59 meq/l. The maximum calcium and magnesium contents were measured in ppt. sample collected on the 24th of December 1988 while the minimum value was recorded on the 13th of March 1989 and on the 4th of January 1990 for Ca & Mg respectively. Calcium ions represented the dominant cation in rain waters collected from this station.

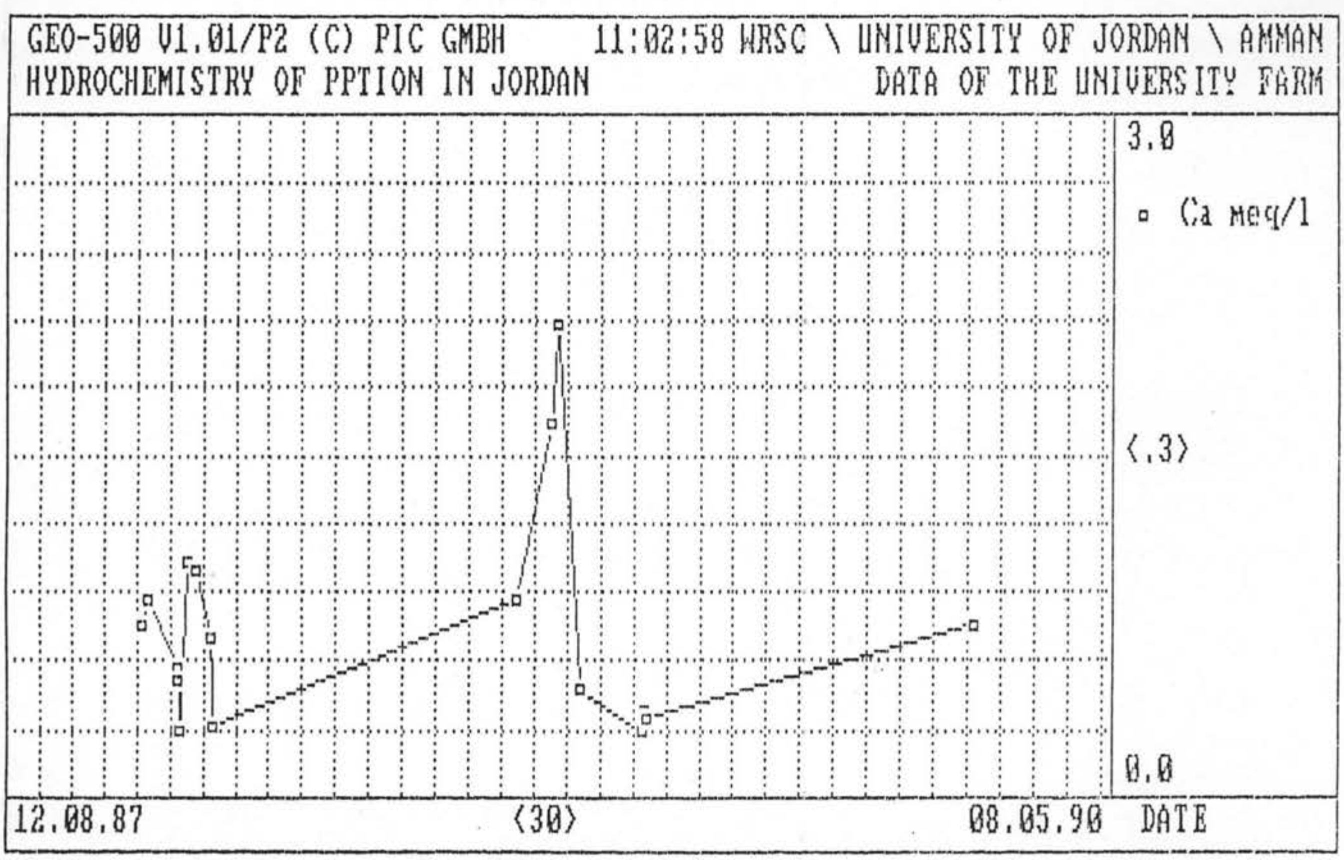
8.5- Alkaline elements (Na^{+} & K^{+})

The sodium concentration ranged from 0.02 to 1.28 meq/l with an average of 0.37 ± 0.34 meq/l, figure (90). The maximum concentration was measured on the 24th of December 1988, while the minimum content was recorded on the 16th of February 1988. Sodium represented the second dominant cations after calcium in most of the analysed samples.

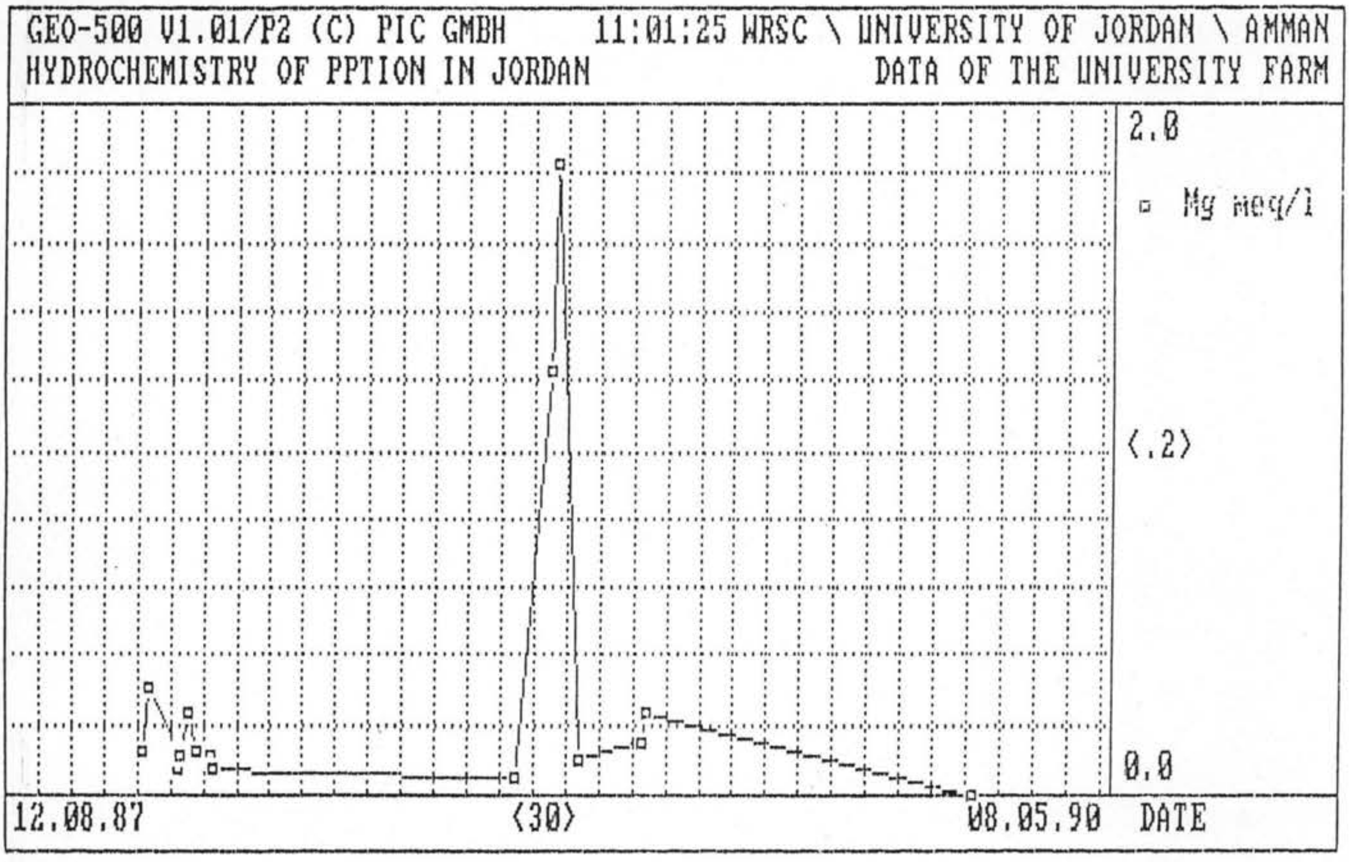
The potassium content in rain water samples was found to range between potassium free waters and 0.14 meq/l ,figure (91) with an average value of 0.037 meq/l. The maximum concentration was measured on the 24th of December 1988 and the minimum value was recorded on the 16th of February 1988.

8.6- Chloride (Cl^{-})

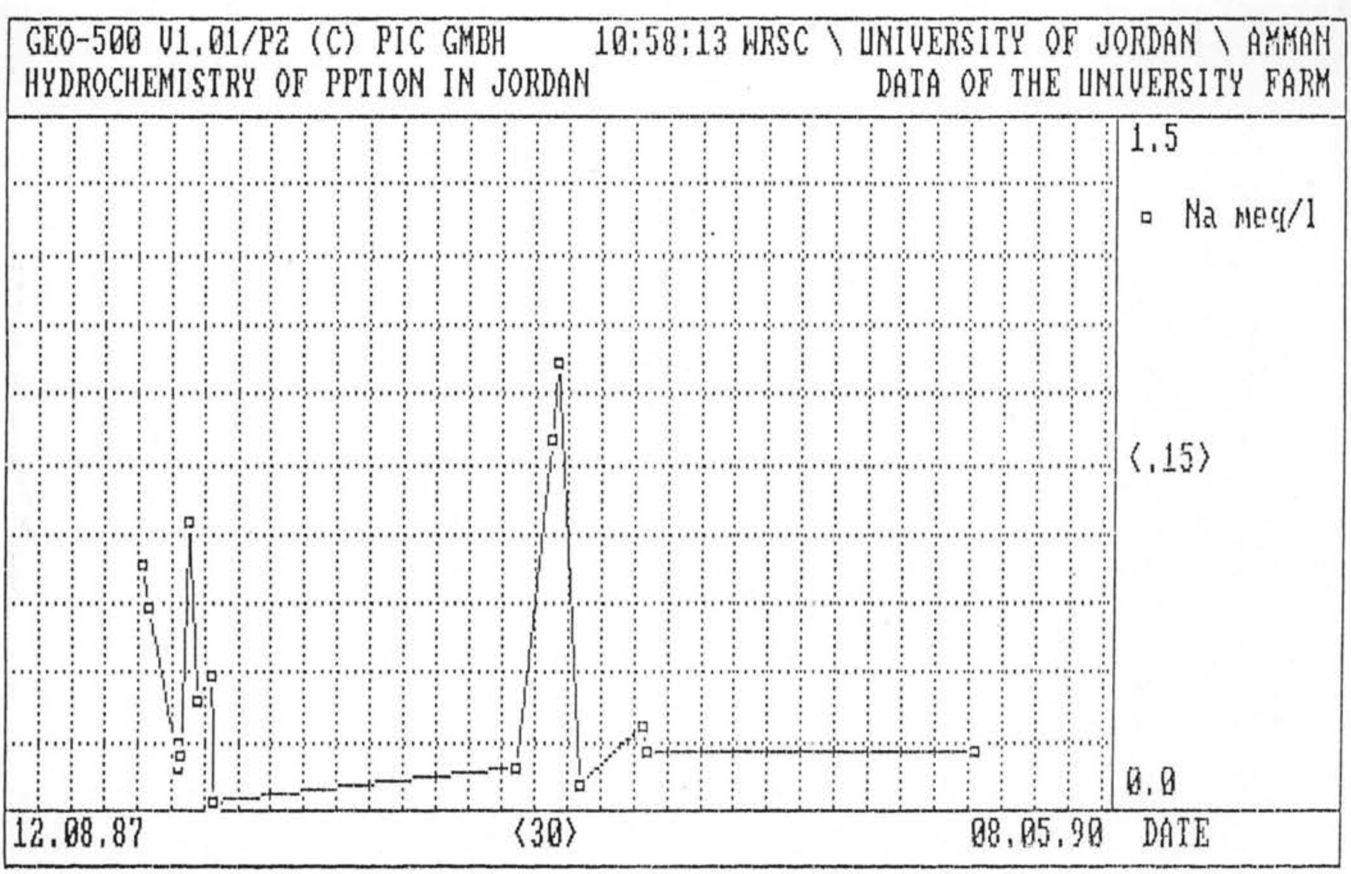
The chloride content in rain water samples collected during



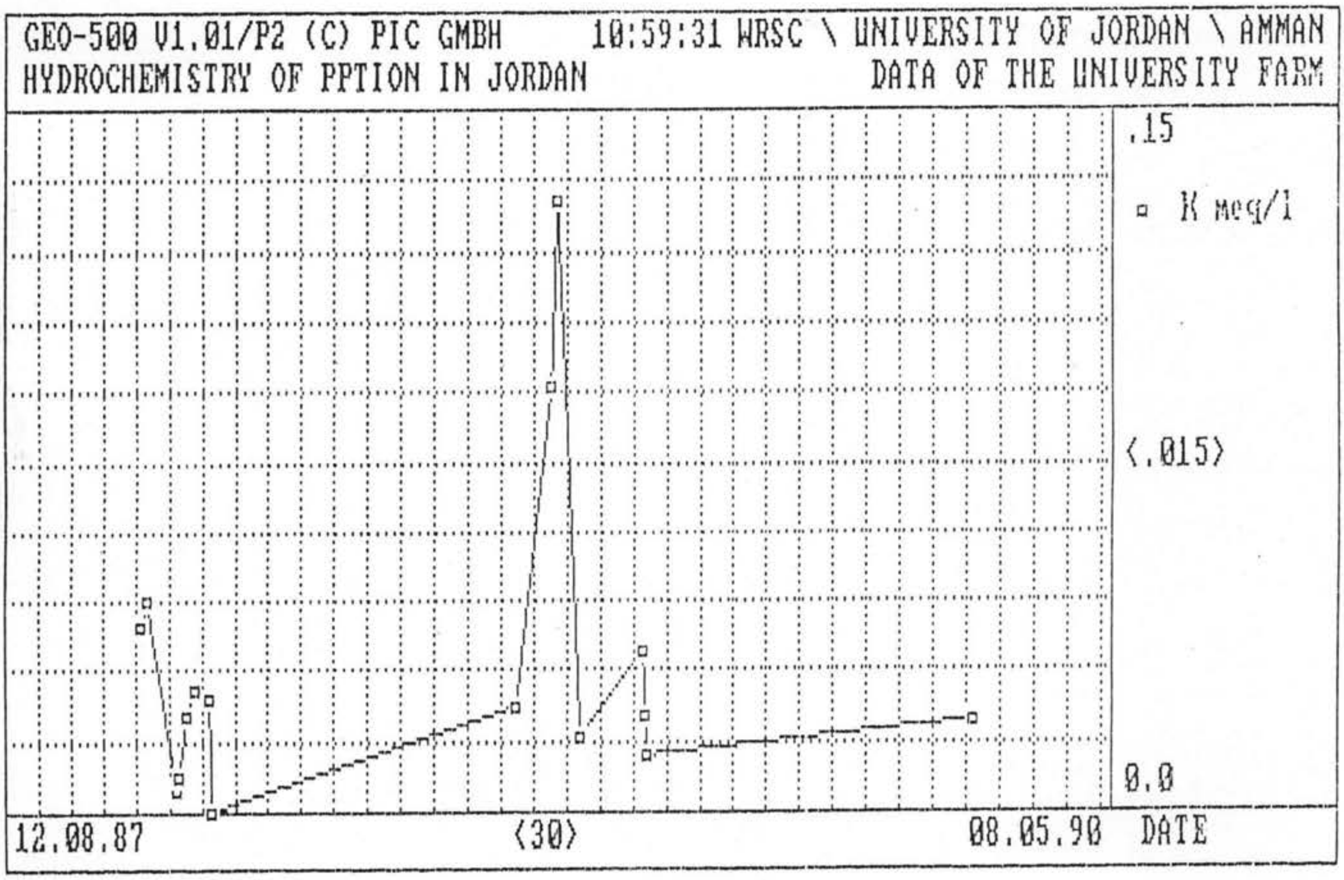
Figure(88): Fluctuations in Ca for University Farm Station



Figure(89): Fluctuations in Mg for University Farm Station



Figure(90): Fluctuations in Na for University Farm Station



Figure(91): Fluctuations in K for University Farm Station the observation period was found to range from 0.095 to 1.554 meq/l, with an average of about 0.47 ± 0.43 meq/l, figure (92). The maximum and the minimum concentrations were recorded in water samples collected on the 24th of December 1989 and on the 13th of March 1988 respectively.

8.7- Sulfate (SO_4^{2-})

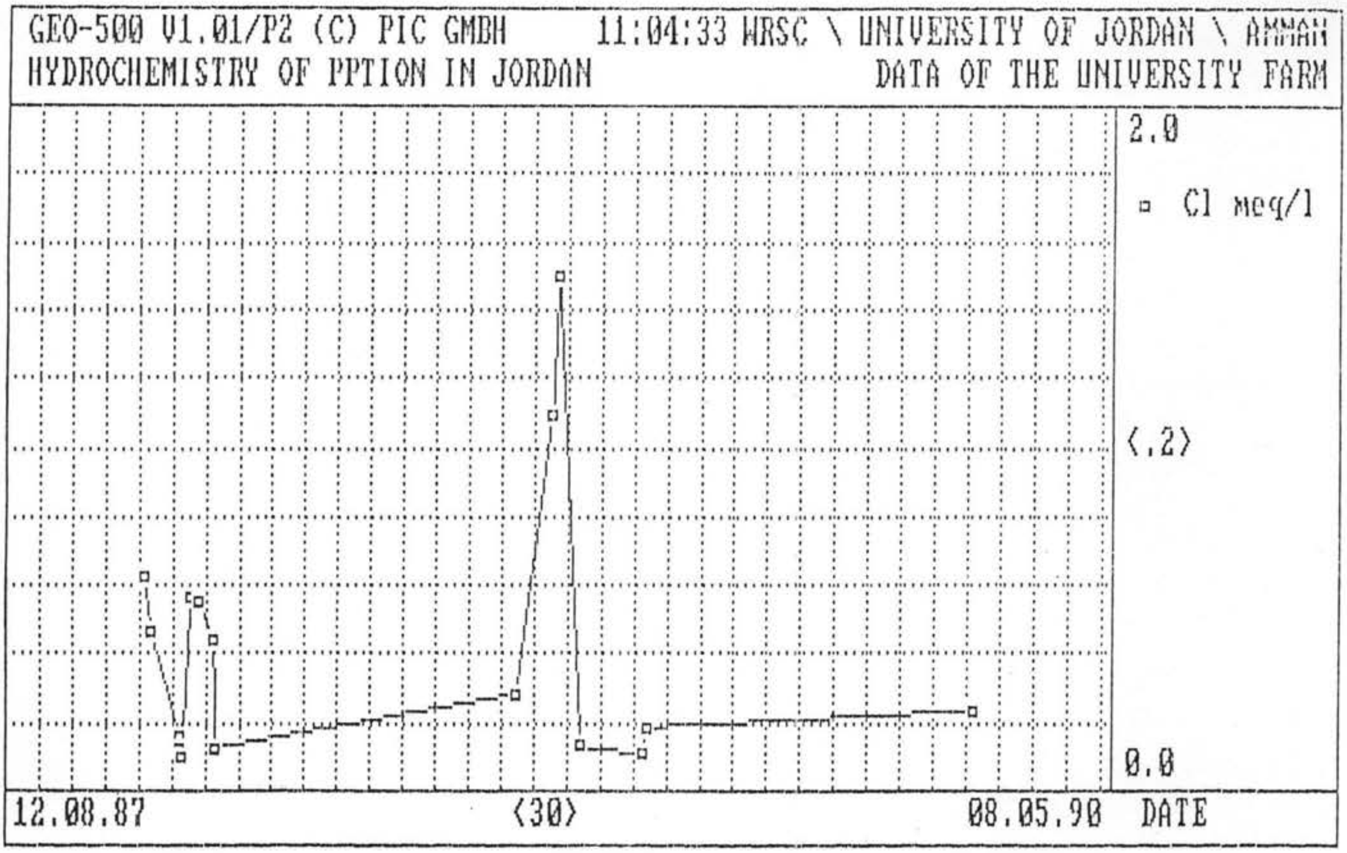
The sulfate content ranged from 0.081 to 1.008 meq/l, with an average of 0.35 ± 0.26 meq/l. The maximum content in rain water collected from this station was on the 24th of December 1988, while the minimum content was recorded on the 16th of February 1988. Figure (93) shows the fluctuation in the sulfate content during the study period.

8.8- Nitrate (NO_3^-)

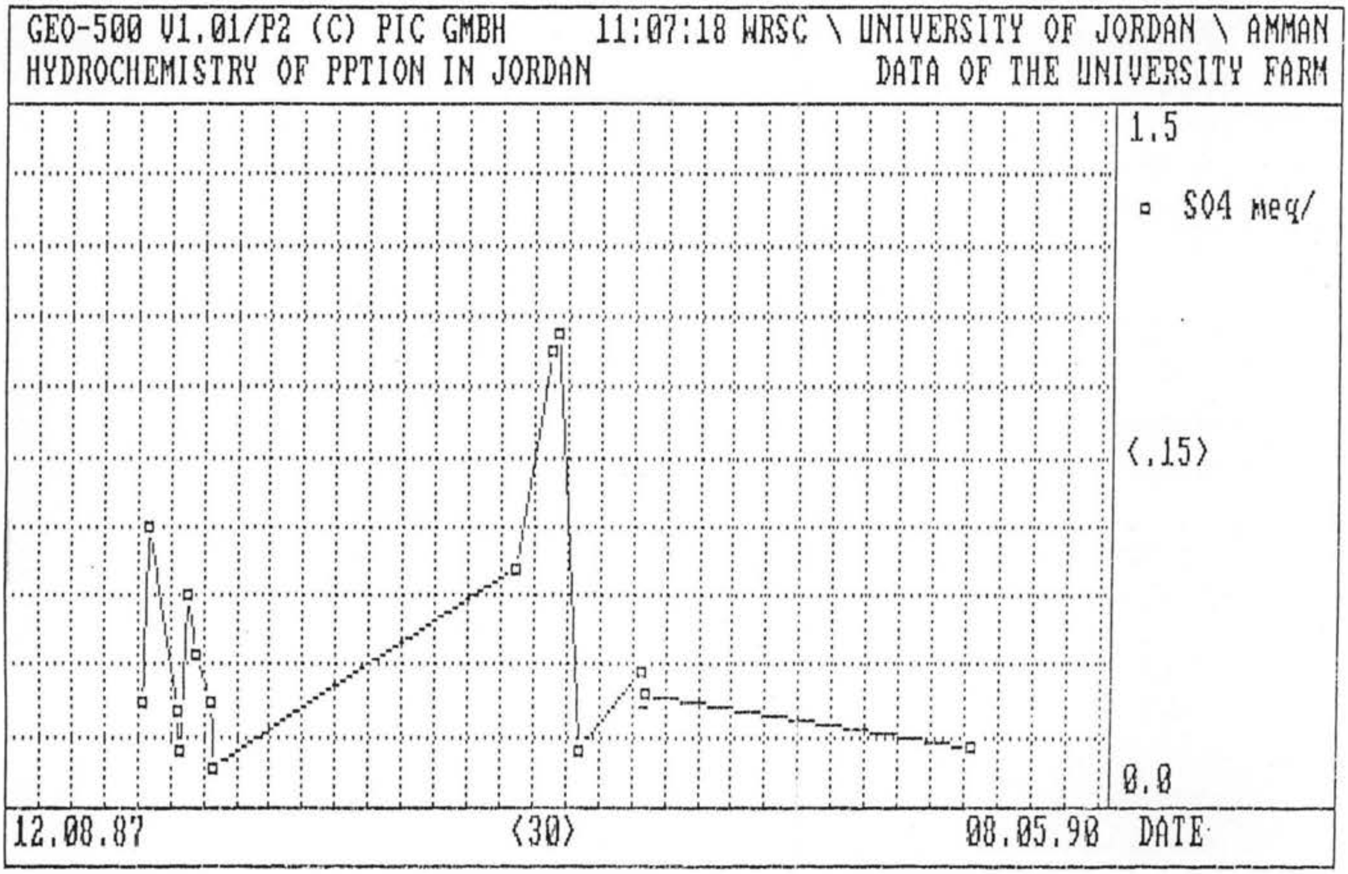
Figure (94), shows the fluctuations of the nitrate content during the observation period. The nitrate concentration was found to range from 0.021 to 0.125 meq/l with an average of 0.062 ± 0.030 meq/l. The maximum concentration was measured in water samples collected on the 15th of February 1988. The maximum recorded concentrations were found to correlate directly with the thunderstorms affecting the area.

8.9- Bicarbonate (HCO_3^-)

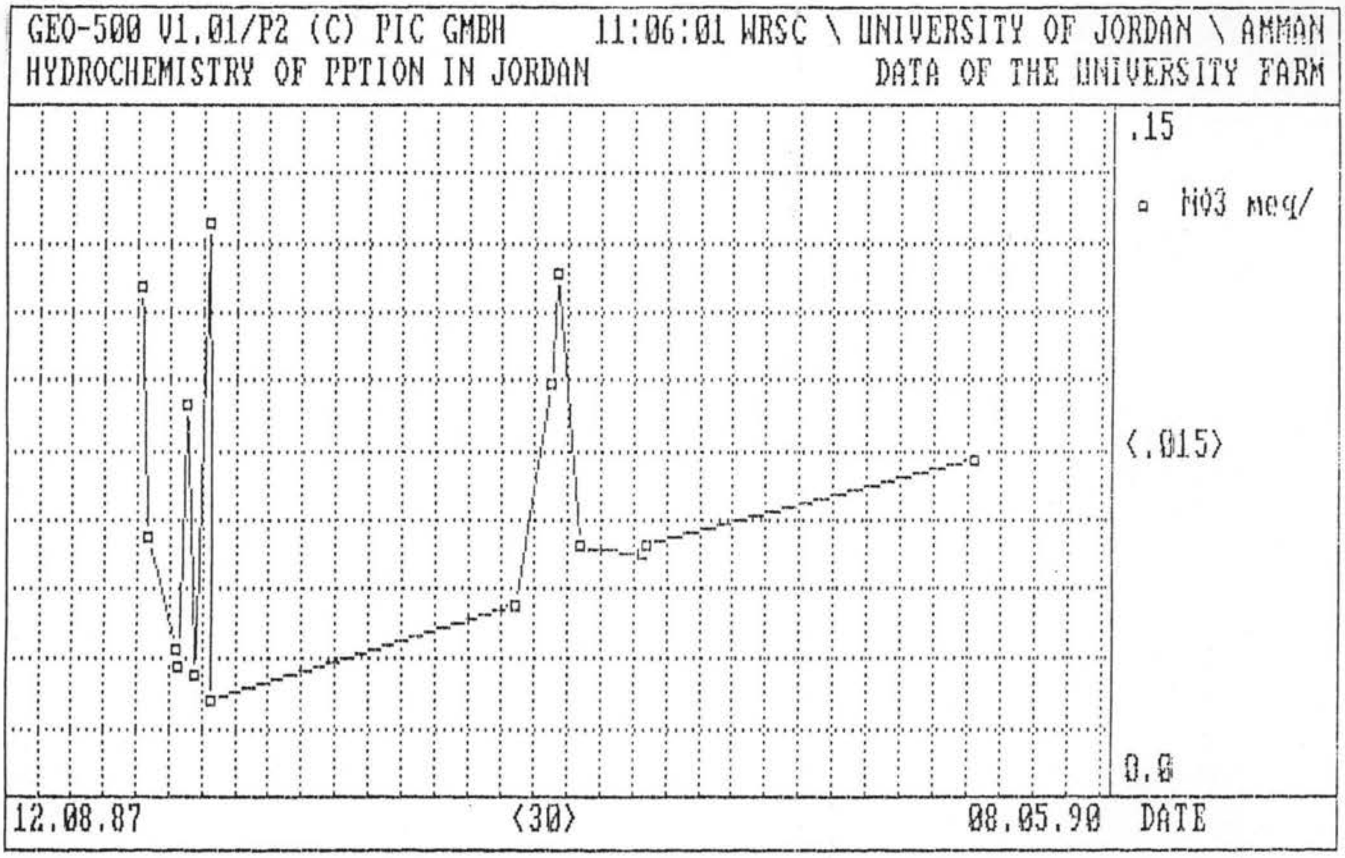
The bicarbonate content ranged from 0.19 to 2.60 meq/l, with an average of 0.71 ± 0.069 meq/l, figure (95). The maximum bicarbonate concentration in rainwater samples was recorded on the 24th of December 1988, and the minimum content was measured in water sample collected on the 13th of March 1989.



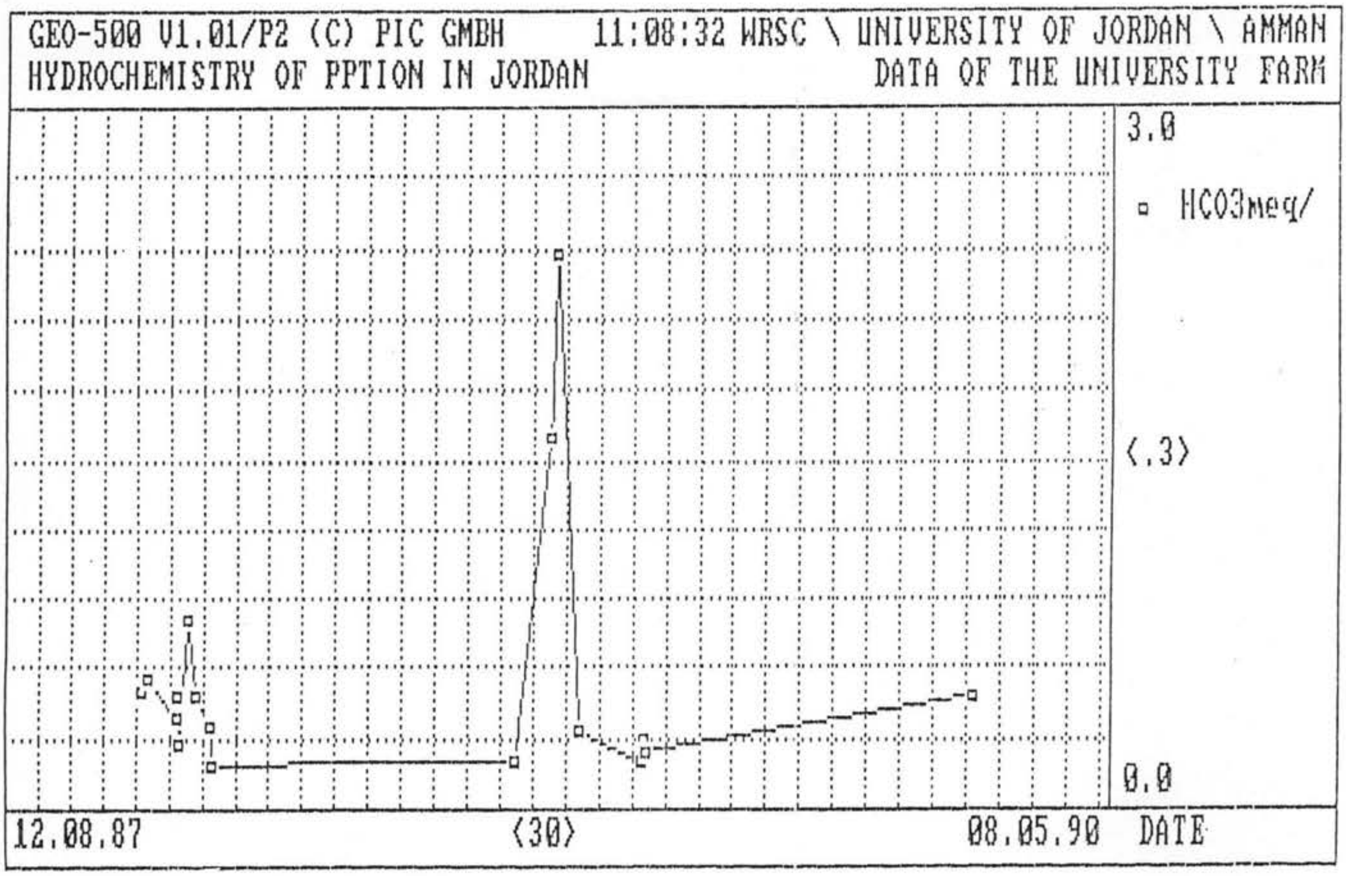
Figure(92) Fluctuations in Cl for University Farm Station



Figure(93): Fluctuations in SO_4 for University Farm Station



Figure(94): Fluctuations in NO_3 for University Farm Station



Figure(95): Fluctuations in HCO_3 for University Farm Station

9- Muwaqqar Station

In the central part of Jordan to the south east of Amman two stations were installed to collect ppt. water. The first one in Muwaqqar area (the University Farm) and the second in the treatment plant of Queen Alia International Airport. From the first station, seventeen water samples were collected during the first year 1987/1988 while twenty five samples were collected during the hydrologic years 1987/1988 and 1988/1989 from the second station. The descriptive statistics of the analysed parameters of the two station are shown in tables (11 and 12). No major differences between the quality of ppt. in the two stations were detected.

The quality of ppt. water is a function of many variables such as the origin of the storm depression, i.e. whether it comes from the north, south or west, and to the direction of the depression invading the country. The fluctuations in the analysed parameters of Muwaqqar station (station No.1) will be considered to represent the two stations.

Concentrations and Fluctuations of the Physical and Chemical Parameters.

9.1- Amount rainfall (mm) :

The amount of ppt. from which water samples were collected and analysed for the different parameters was found to range from 0.4 to 23 mm, during the period 1989-1990, figure (96). The maximum amount of ppt. was measured on the 13th of March 1990, where a composite water sample was collected.

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HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-QAIA VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32066.0	32140.0	32088.000	29.198
QUANT mm	0.8	4.8	2.720	1.555
TEMP °C	15.4	20.2	18.025	2.488
pH VALUE	7.68	9.03	8.0540	0.5528
EC µS/cm	83.0	315.0	206.000	93.247
Na meq/l	0.037	0.900	0.45316	0.40338
K meq/l	0.019	0.147	0.08449	0.06000
Mg meq/l	0.000	0.885	0.22309	0.37466
Ca meq/l	0.443	2.028	1.29927	0.74243
Cl meq/l	0.160	0.791	0.50560	0.28657
NO3 meq/	0.036	0.621	0.30482	0.22931
SO4 meq/	0.062	1.778	0.79416	0.67062
HCO3 meq	0.245	0.808	0.45532	0.21956
TC meq/l	0.830	3.150	2.06000	0.93247
TA meq/l	0.830	3.150	2.06000	0.93247
I mg/l	0.020	0.038	0.02933	0.00902
Br mg/l	0.010	0.260	0.09333	0.14434
F mg/l	0.045	0.066	0.05550	0.01485
Ag mg/l	0.00000	0.00500	3.750E-03	2.500D-03

Table(11): Descriptive Statistics for Queen Alia Intr. Airport

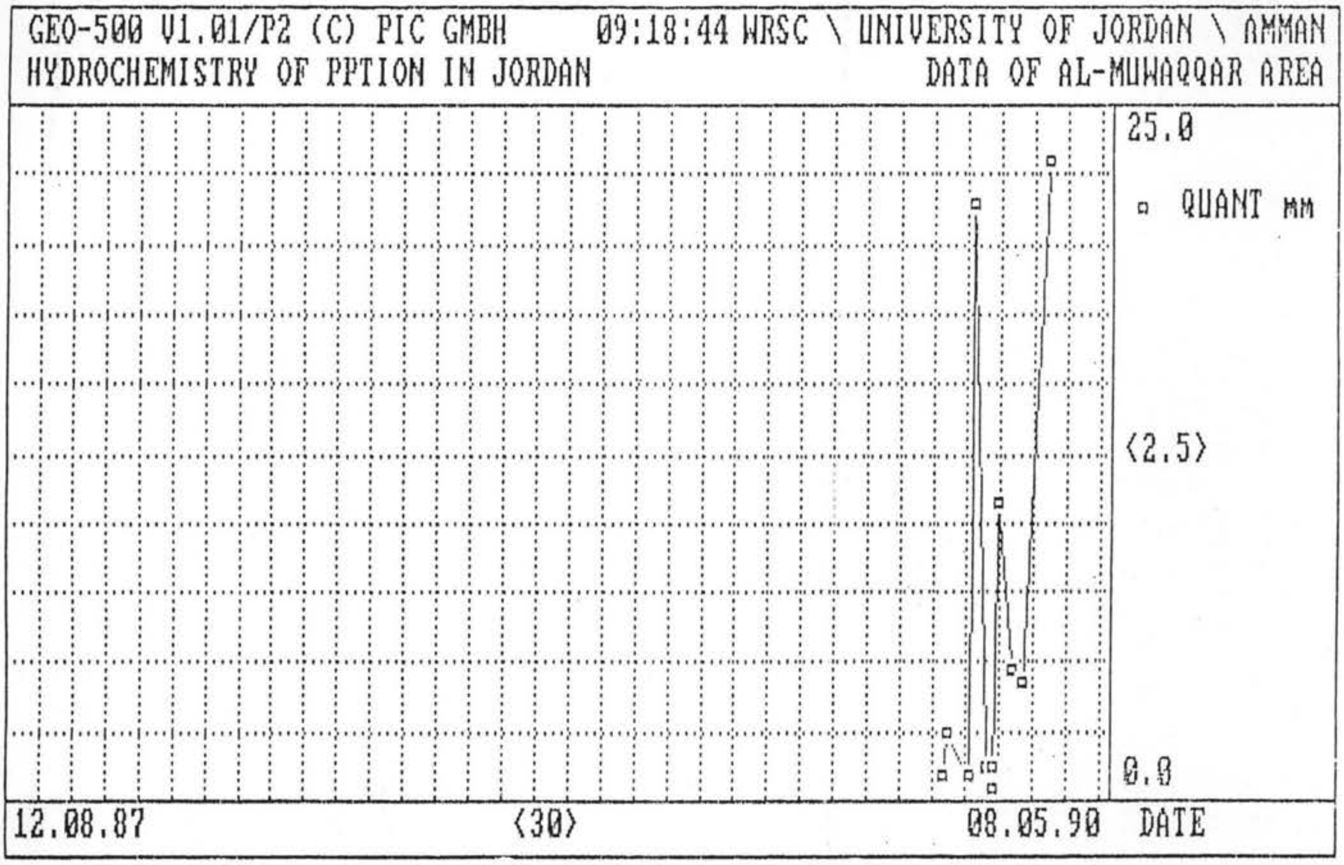
STASY V7.02/12 (C) PIC GMBH WRSC UNIV.JORDAN 10.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-MUWQ VOM 15.07.15

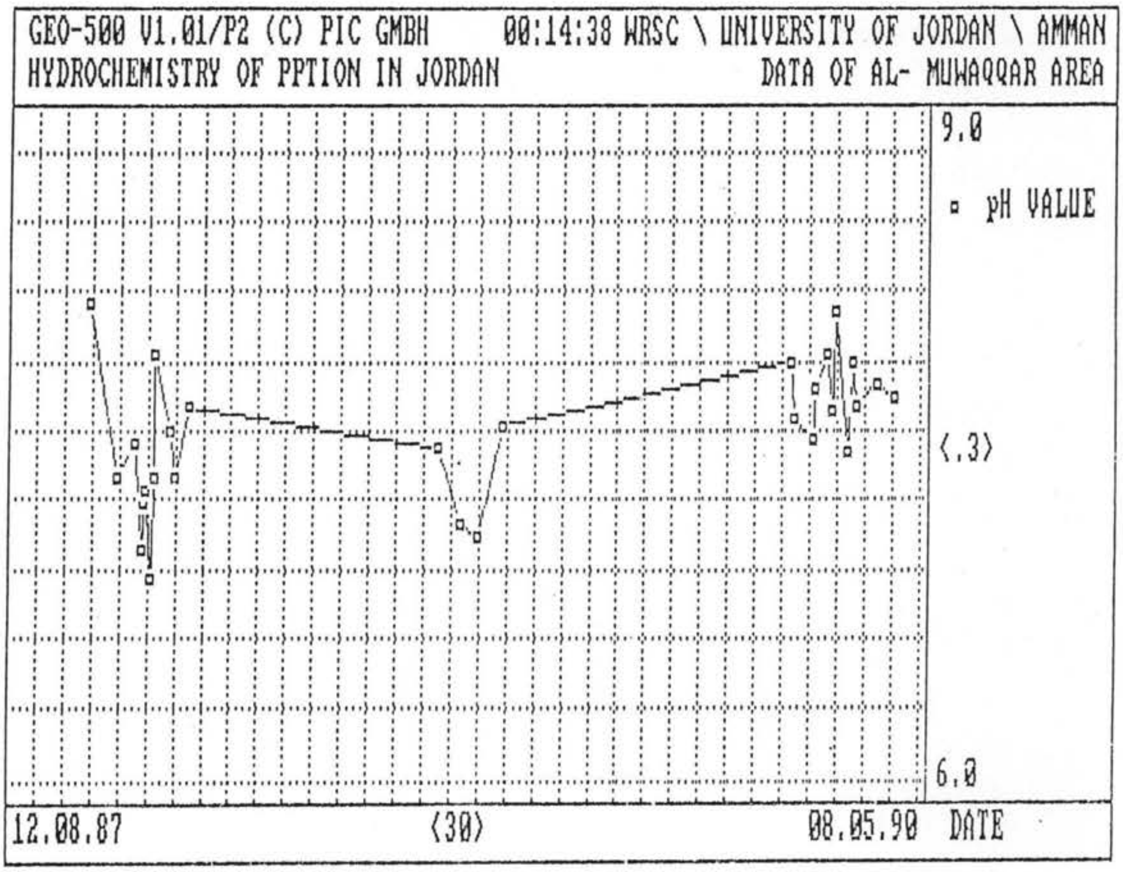
2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32086.0	32963.0	32533.773	355.779
QUANT mm	0.4	23.0	6.050	8.089
TEMP °C	16.2	18.6	16.600	0.980
pH VALUE	4.00	8.15	7.4821	0.7372
EC µS/cm	30.0	373.0	165.077	101.292
Na meq/l	0.020	1.189	0.34424	0.28672
K meq/l	0.001	0.144	0.03727	0.03983
Mg meq/l	0.000	0.751	0.20356	0.22581
Ca meq/l	0.211	2.920	1.06569	0.65364
Cl meq/l	0.067	2.780	0.58456	0.56776
NO3 meq/	0.009	0.363	0.09401	0.07292
SO4 meq/	0.024	1.909	0.32569	0.37941
HCO3 meq	0.093	4.934	0.92866	1.03810
TC meq/l	0.300	3.730	1.65076	1.01292
TA meq/l	0.300	3.730	1.65077	1.01292
I mg/l	0.000	0.026	0.01261	0.00935
Br mg/l	0.001	0.565	0.12942	0.17741
F mg/l	0.012	0.353	0.08110	0.10338
PO4 mg/l	0.155	0.510	0.32500	0.12309
TOC mg/l				
Li mg/l	0.000	0.130	0.03426	0.03048
TURBIDY	6.0	110.0	41.133	30.071
COLOR	3.0	70.0	20.633	19.720
TDS 104°	0.010	0.480	0.14500	0.11713
TDS 180°	0.000	0.455	0.12594	0.11503
Ag mg/l	0.00000	0.34800	2.957E-02	8.137D-02
TIME hr				
Fe mg/l	0.01800	2.58000	1.227E+00	1.066D+00
Cu mg/l	0.00110	0.01380	6.150E-03	4.653D-03
Mn mg/l	0.00000	0.06300	2.395E-02	2.545D-02
Zn mg/l	0.01550	0.79200	2.802E-01	3.775D-01
Pb mg/l	0.00000	0.00750	2.472E-03	2.921D-03
Cr mg/l	0.00000	0.00300	1.000E-03	1.549D-03
Ni mg/l	0.00000	0.04350	1.000E-02	1.769D-02
Sr mg/l				

Table(12): Descriptive Statistics for Muwaqqar Station



Figure(96): Fluctuations in ppt. Amounts for Muwaqqar Station



Figure(97): Fluctuations in pH for Muwaqqar Station

9.2- pH-value :

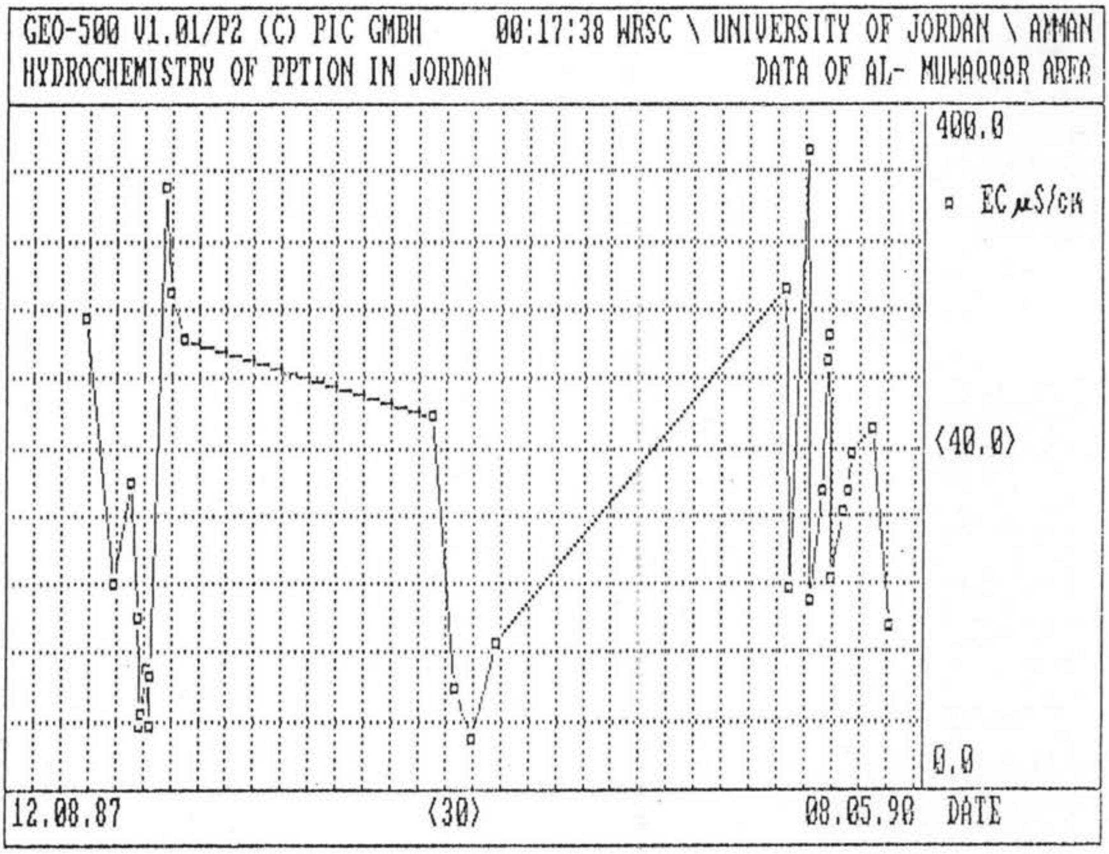
The pH-value of rain water samples collected from this station ranged from 6.95 to 8.15, with an arth. mean of 7.59 ± 0.29. Figure (97) shows the fluctuation of the measured pH-values during the study period. Generally, the pH-value of rain water collected during the hydrologic year 1988/1989 were lower than that of the hydrologic year 1987/1988. The minimum value was recorded on the 11th of January 1988, while the maximum was recorded on the 6th of November 1987.

9.3- Electrical conductivity (Ec µs/cm at 25 °C)

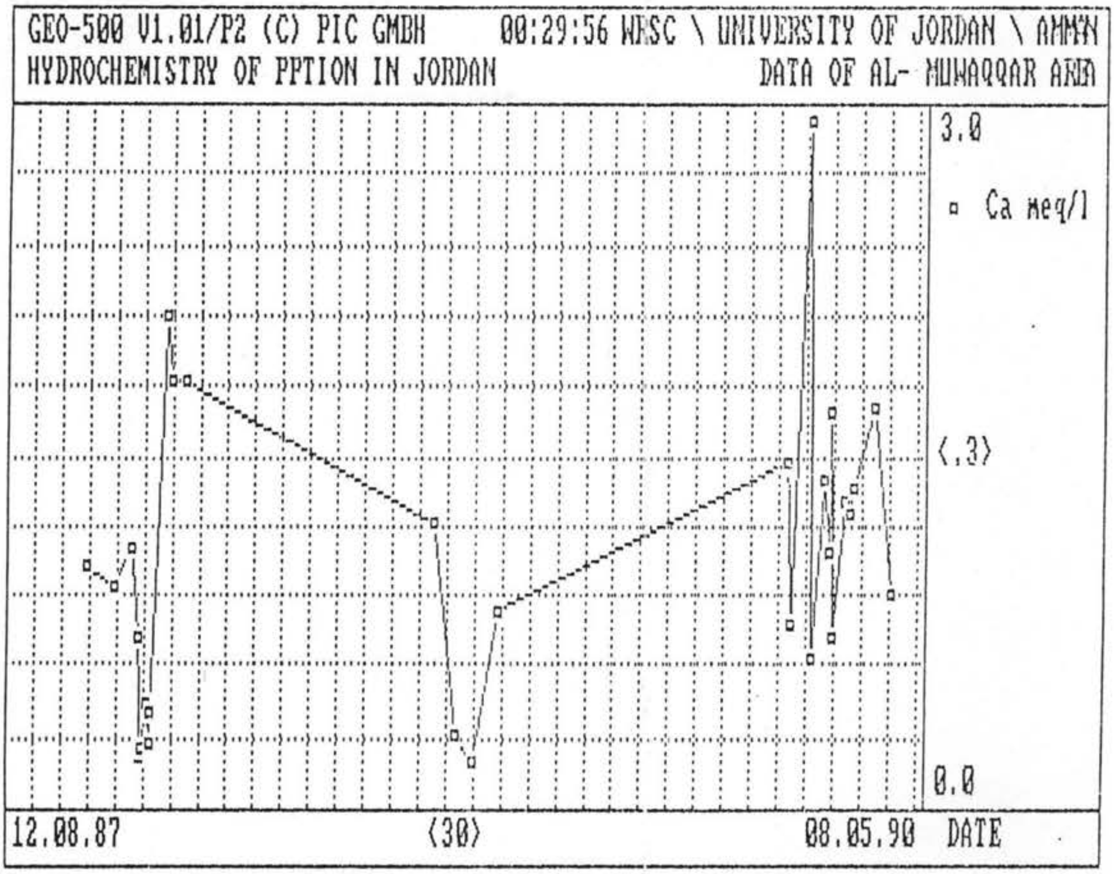
The EC ranged from 30 to 373 us/cm with an average of 164.5 ± 98.71 µs/cm, figure (98). The maximum EC of the hydrologic year 1987/1988 was recorded at the beginning of the rainy season after that the EC of rain water tended to decrease and reached a minimum on the 4th of January, 1988. The maximum EC value during the study period was recorded on the 2nd of January 1990,while the minimum was recorded on the 2nd of January 1989. Generally, the EC values of ppt. water samples collected during the hydrologic year 1988/1989 were higher than those of the previous hydrologic year.

9.4- Earth Alkaline Elements (Ca^{2+} & Mg^{2+})

The calcium content of rain water collected from this station represented the dominant cation. Its concentration ranged from 0.21 to 2.92 meq/l, with an arth. mean of 1.06 ± 0.65 meq/l, figure (99). The minimum calcium content was measured on the 4th of January 1988, while the maximum recorded value was on the 2nd of January 1990. The magnesium content



Figure(98): Fluctuations in EC for Muwaqqar Station



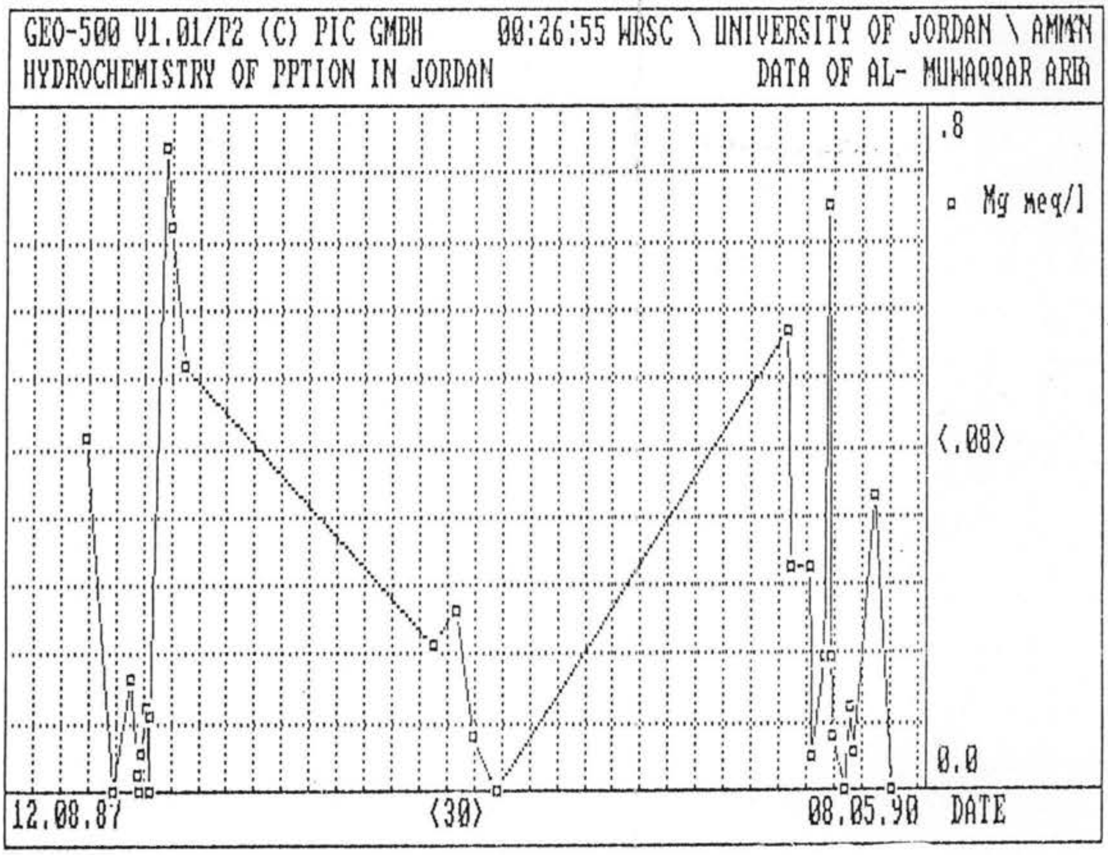
Figure(99): Fluctuations in Ca for Muwaqqar Station ranged from magnesium free waters to 0.75 meq/l with an average of 0.20 ± 0.23 meq/l, figure (100). The maximum content was measured in rain water sample collected on the 1st of February 1989. While minimum was measured few times.

9.5- Alkaline Elements (Na^+ & K^+)

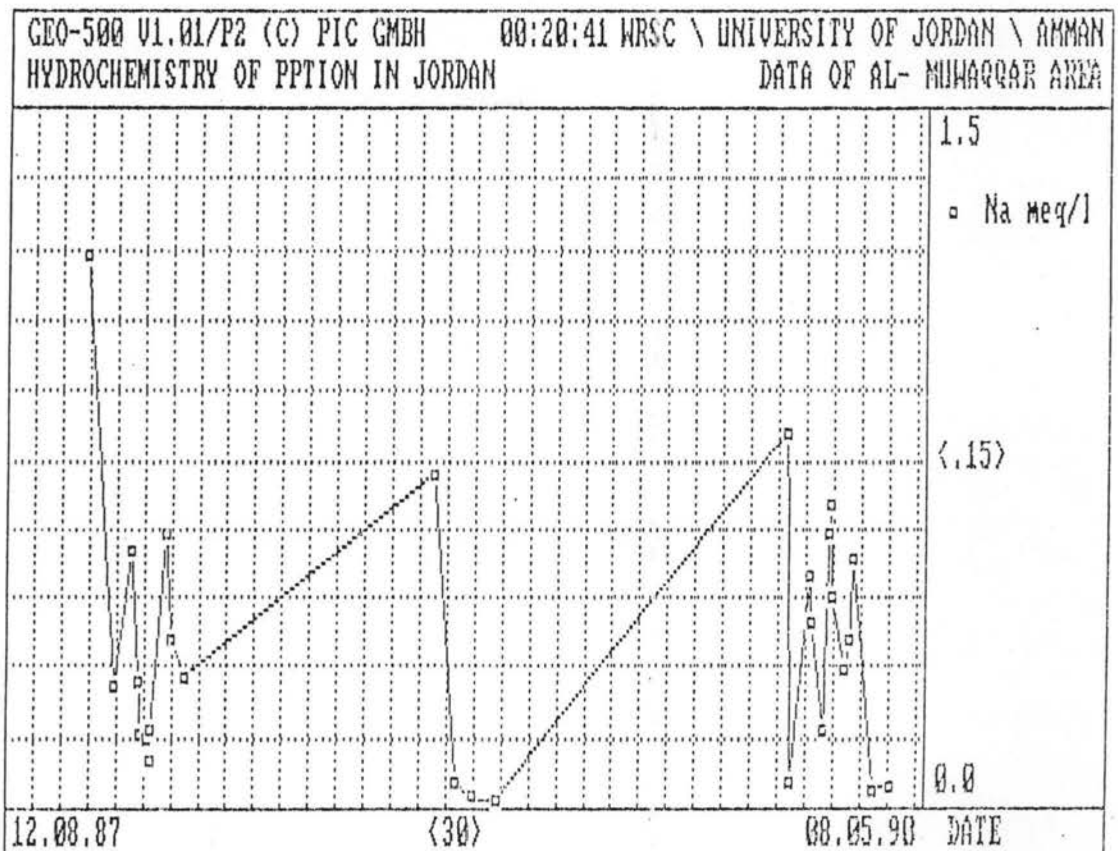
The alkaline elements in rain water samples collected from Muwaqqar represented about 25 % of the total cations. Figures (101 and 102) show the fluctuations of sodium and potassium ions concentrations during the study period. The sodium content ranged from 0.02 to 1.19 meq/l, with an average of 0.34 ± 0.28 meq/l. The maximum Na-content was measured on the 6th of November 1987, while the minimum value was recorded on the 28th of January 1989, when successive cold depressions affected Jordan. The maximum K-content was recorded in ppt. water collected on the 6th of November 1987, at the beginning of the rainy season, while minimum K-concentration was measured in rain water samples collected on the 5th and 15th of January 1988. The potassium content ranged from almost potassium free water to 0.144 with an average value of 0.03 ± 0.04 meq/l.

9.6- Chloride (Cl^-)

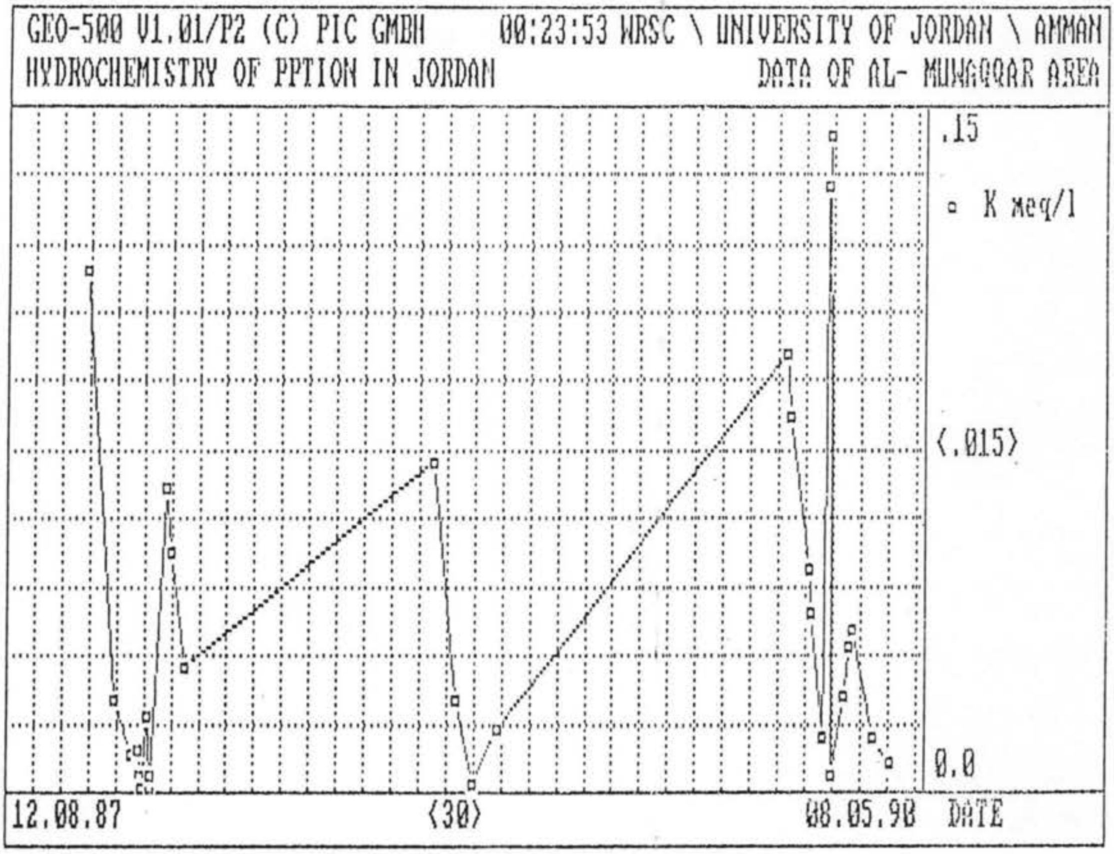
The chloride content ranged from 0.067 to 2.78 meq/l. The arth. mean was found to be 0.576 ± 0.568 meq/l. The maximum chloride content was measured on the 7th of February 1988 and the minimum value was recorded in ppt. sample collected on the 13th of December 1988 , figure (103).



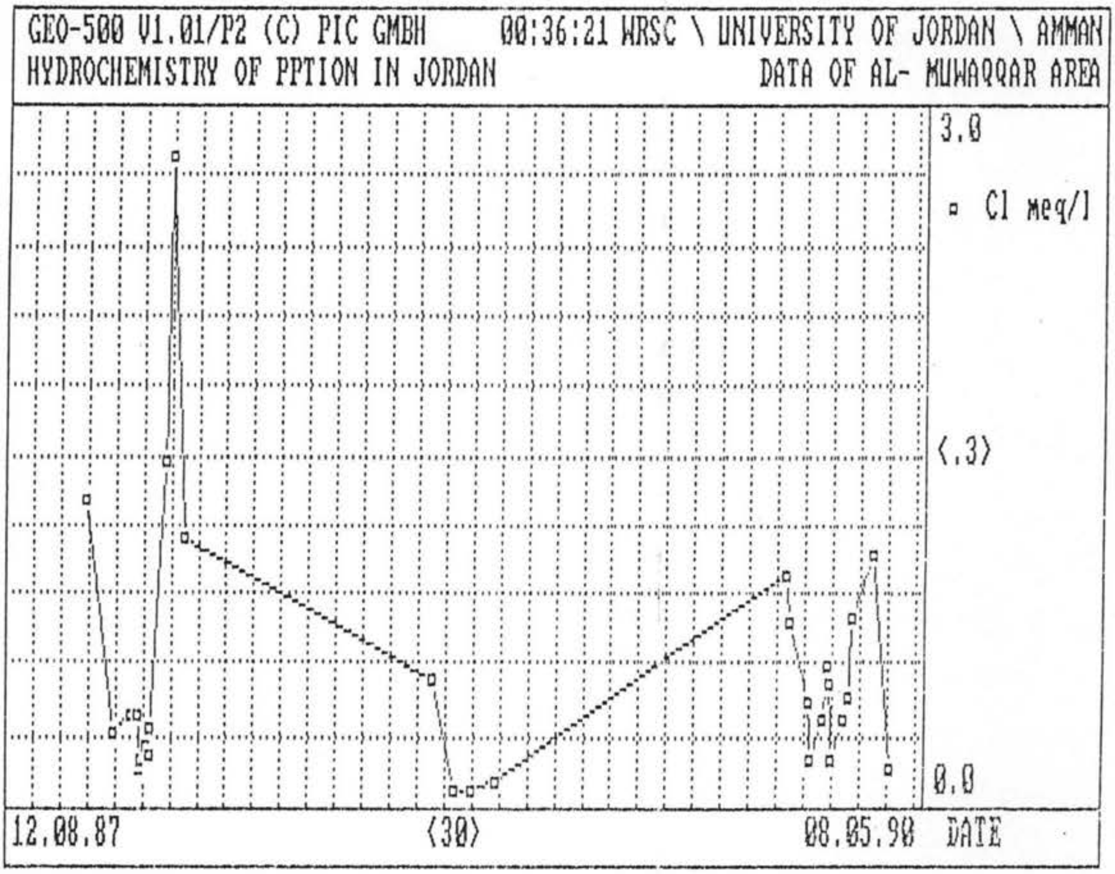
Figure(100): Fluctuations in Mg for Muwaqqar Station



Figure(101): Fluctuations in Na for Muwaqqar Station



Figure(102): Fluctuations in K for Muwaqqar Station



Figure(103): Fluctuations in Cl for Muwaqqar Station

9.7- *Sulfate (SO_4^{2-})*

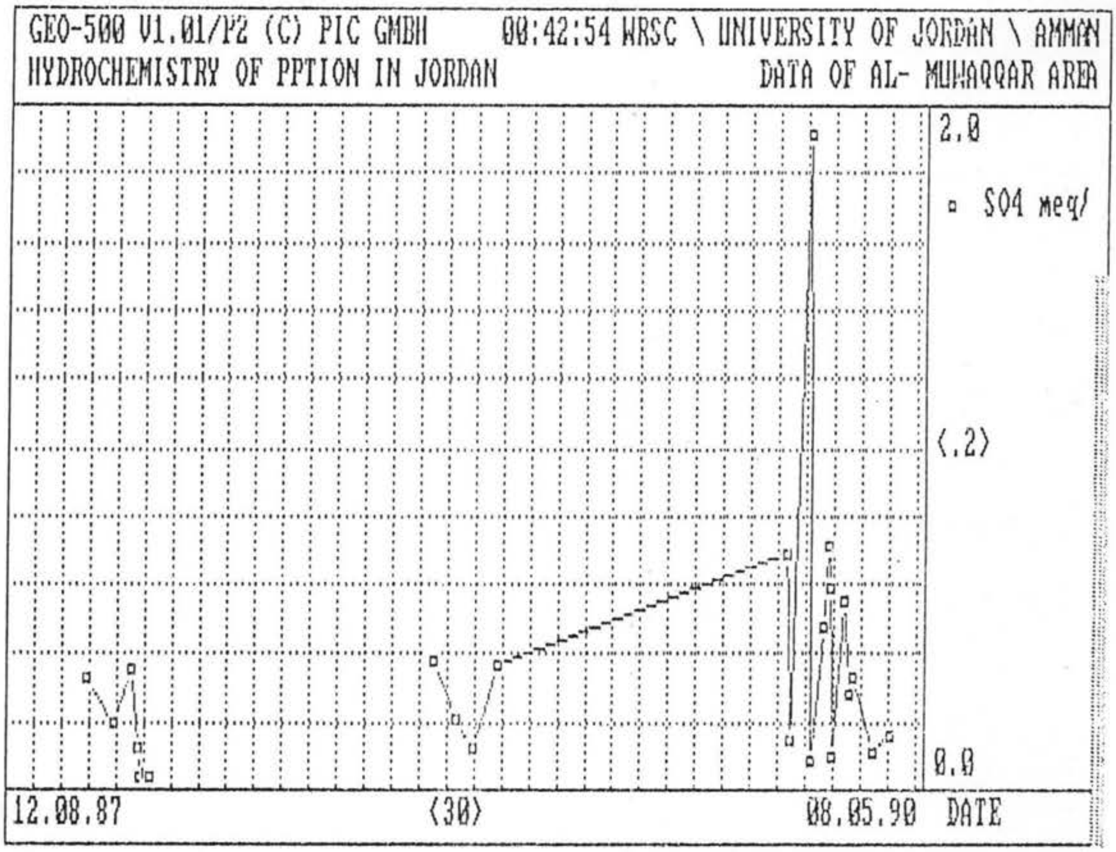
The fluctuation of sulfate contents in rain water samples is represented in figure (104). The sulfate content was found to range from 0.024 to 1.909 meq/l, with an arth. mean of 0.32 ± 0.38 meq/l. The maximum recorded concentration of sulfate was found in ppt. water collected on the 2nd of January 1990, and the minimum value was measured on the 5th of January 1988, when heavy cold and warm depressions affected Jordan and intensive ppt. occurred.

9.8- *Nitrate (NO_3^-)*

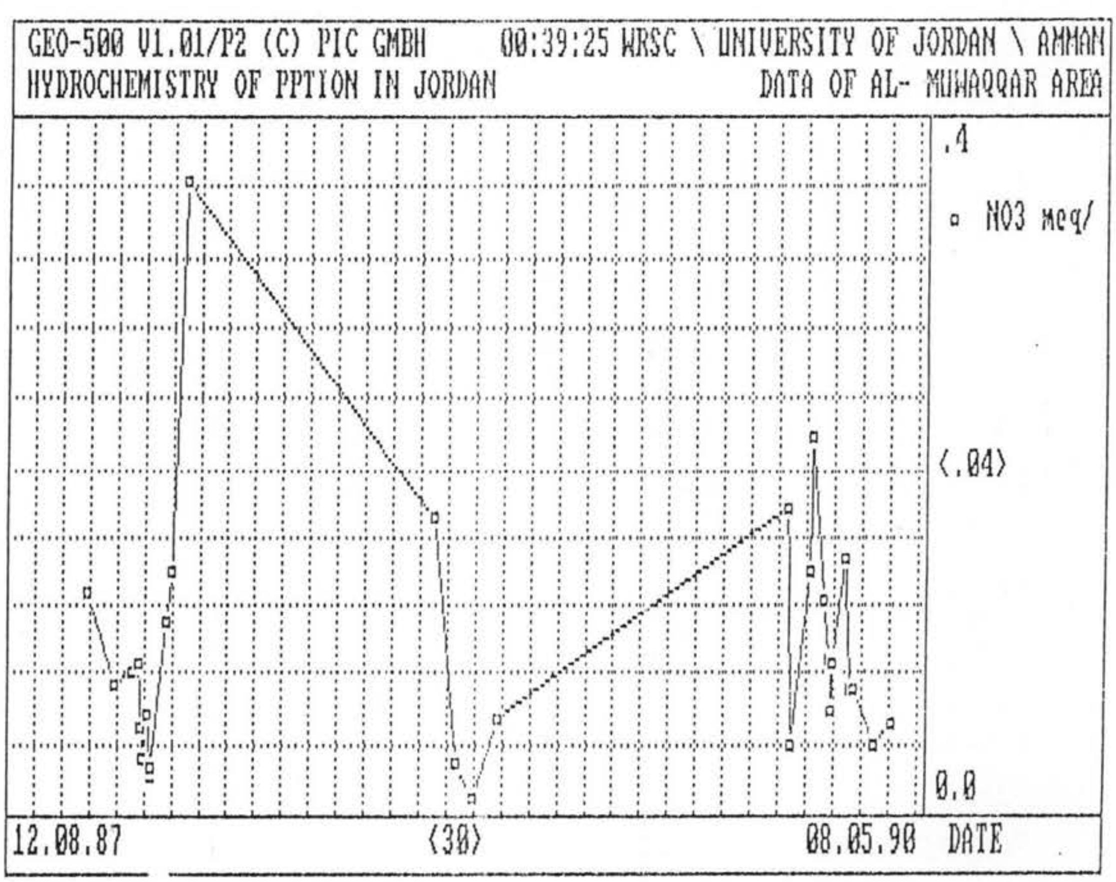
The nitrate content ranged from 0.009 to 0.217 meq/l, with an average of 0.083 ± 0.052 meq/l, figure (105). The maximum nitrate content was measured in rain water samples associated with intensive thunderstorms in north Jordan on the 3rd of January 1990. The minimum nitrate content was recorded in the previous hydrologic year 1988/1989 where successive depressions affected Jordan on the 2nd of January 1989.

9.9- *Bicarbonate (HCO_3^-)*

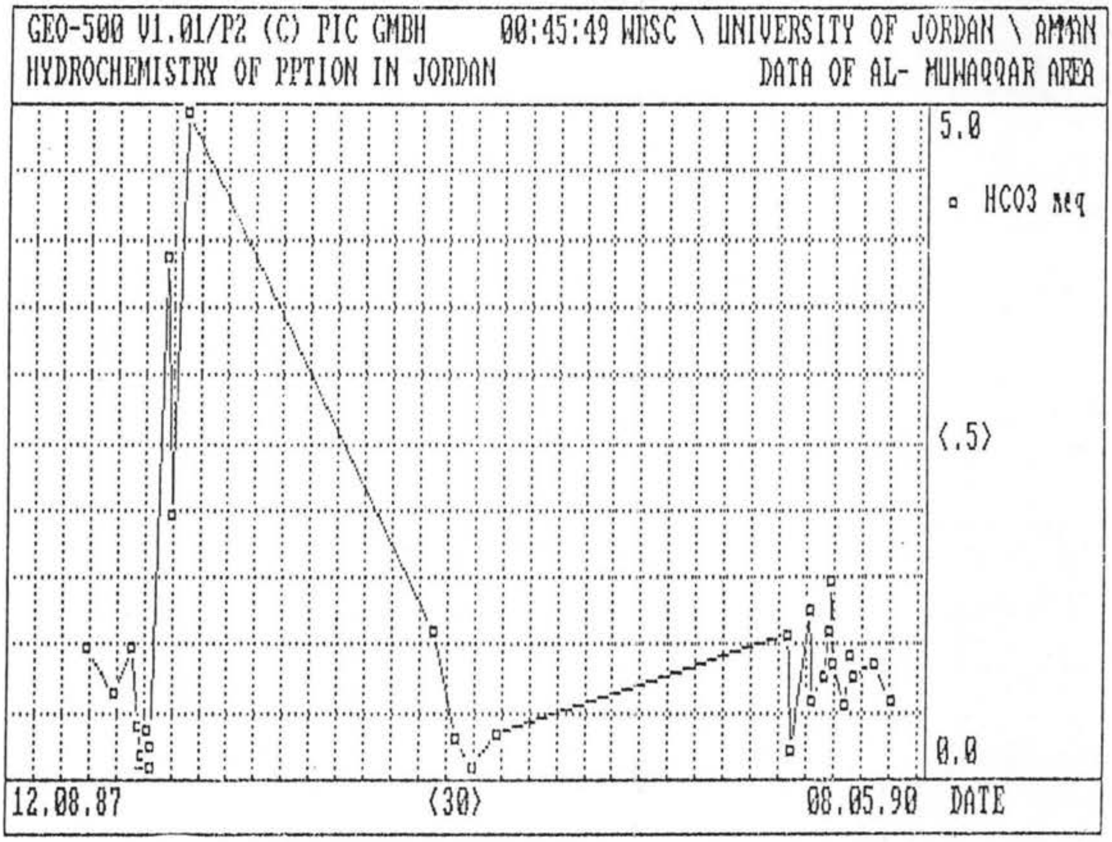
The bicarbonate fluctuations are presented in figure (106). The bicarbonate content during the study period was found to range from 0.093 to 3.880 meq/l, with an average of 0.77 ± 0.73 meq/l. The maximum value was measured on the 1st of February 1987, and the minimum content was recorded in the following rainy season (1988/1989) in water sample collected on the 2nd of January 1989.



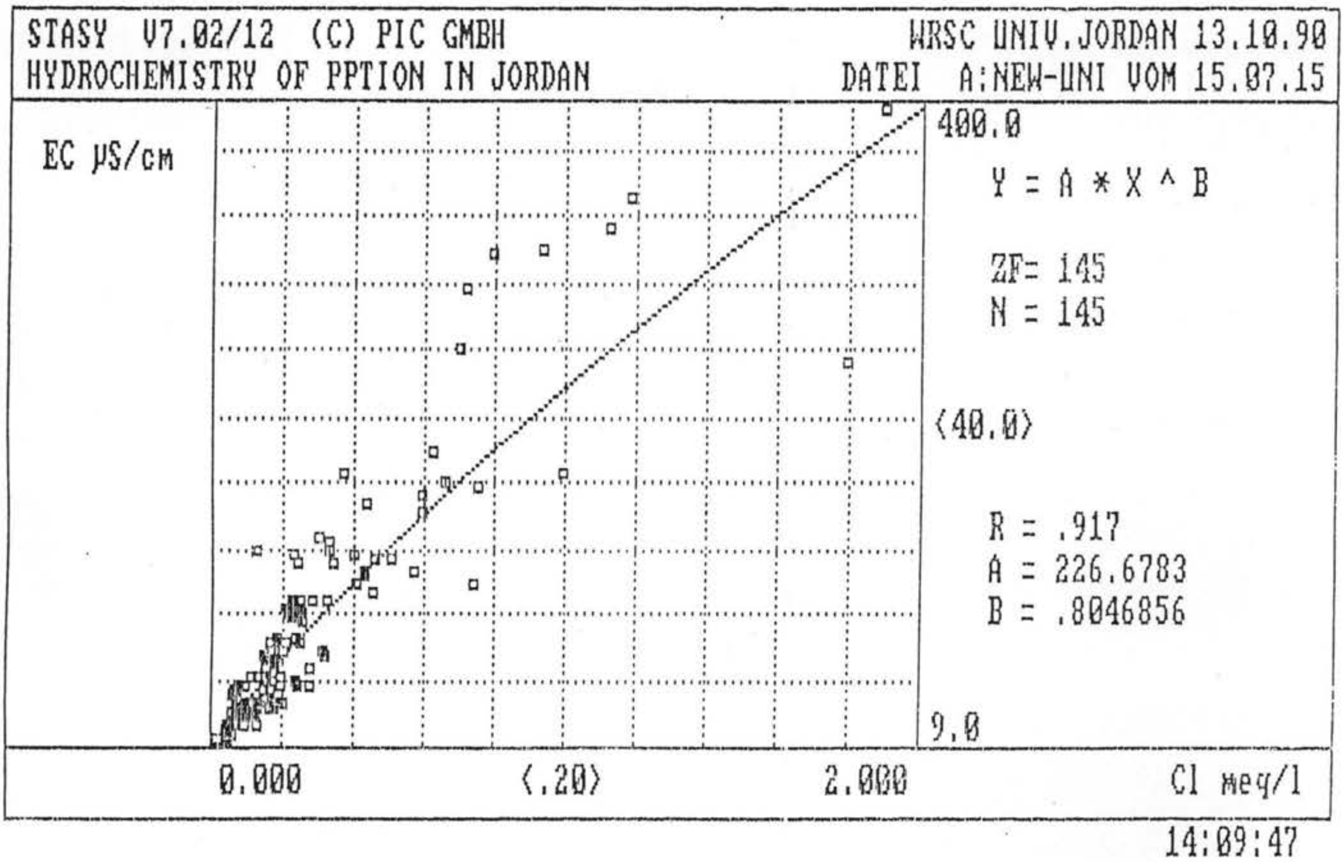
Figure(104): Fluctuations in SO_4 for Muwaqqar Station



Figure(105): Fluctuations in NO_3 for Muwaqqar Station



Figure(106): Fluctuations in HCO_3 for Muwaqqar Station



Figure(107): Relationship between EC and Cl for the University Station

IV- Discussion of Results

University of Jordan Station

Relationships between the analysed parameters :

A product moment correlation between the different physical and chemical characteristics of rain water samples collected from the University of Jordan station is given in table 13. Table 13 shows the correlation matrix of the physical and chemical characteristics of 152 samples. Generally, the amount of rainfall correlates reversely (indirectly) with the analysed parameters, where the higher the amount of rainfall the lower the concentration of the chemical parameters. The parameters which have the highest negative correlation with the amount of rainfall are lithium, sulfate and nitrate , where their significance values are 99.9 %, 99.8 % and 99.0 % respectively. The amounts of rainfall in Jordan are generally a function of the origin of depression affecting it. The most common depressions affecting Jordan are either of Mediterranean Polar, Red Sea or Eastern depressions. Rainfall samples collected from polar and/or Mediterranean depressions usually contained little concentrations of NO_3, Li and sulfate, while the amounts of rainfall were relatively high. The Eastern and Red Sea depressions rainfall amounts are relatively low. Due to their path over the desert, dust materials of different mineral composition such as calcite, quartz, clays and traces of gypsum mix and partially dissolve in the water vapour resulting in higher concentrations of most ions, especially, lithium and sulfate. At the same time Eastern and Red Sea depressions are mostly associated with thunderstorms resulting in the highest recorded nitrate concentrations especially at the beginning of a thunderstorm. The electrical conductivity (EC μs/cm) of rain water samples were found to correlate directly in different degrees with the major cations and anions. The correlation coefficients of EC with Cl, HCO_3, Ca, Na, SO_4, NO_3, Mg, K are 0.900, 0.883, 0,836, 0,819, 0.787, 0.787, 0.583, and 0.552 respectively. The interrelationships between all parameters with each other can be deduced from table (13).

The relation between EC and Cl-content shown in figure 107 was found to fit the following equation.

EC μs/cm = 225.32 + 0.82 [Cl] , r = 0.917 .

Figure (107) shows that the few samples which had the highest EC values also had the highest Cl concentrations. Three samples were collected from rainfall events originating from Red Sea and Eastern depressions where the amounts of precipitation. were found to be very low.

Figure 108 shows the relationship between EC μs/cm and HCO_3 concentration in meq/l. This relation fits the following equation.

EC μs/cm = 17.61 + 210.05 [HCO_3] meq/l , r= 0.889

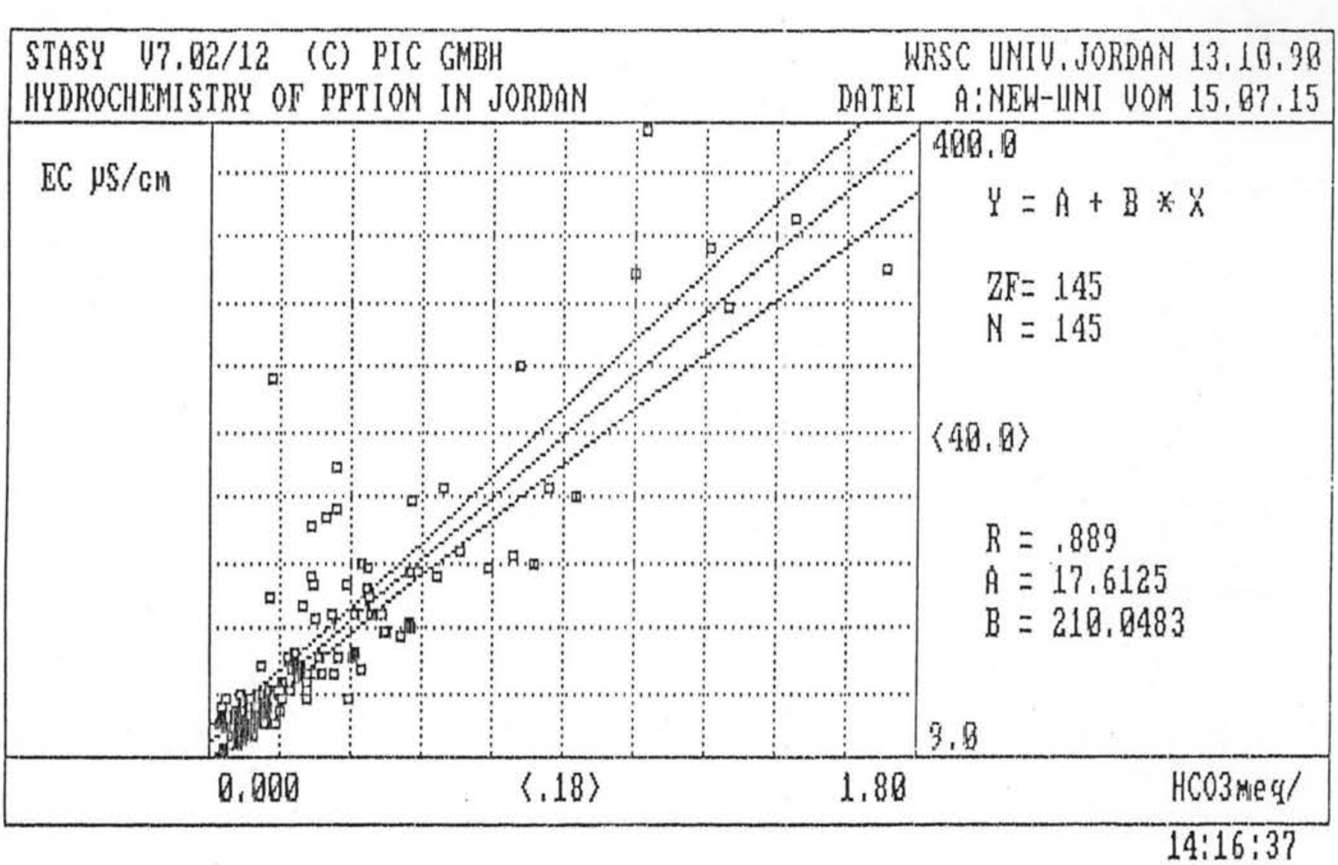
Generally, the bicarbonate and chloride contents of rainwater samples collected from the University of Jordan station showed the same fluctuations as in the case of EC values.

On the other hand, the calcium and sodium ions represented the major cations affecting the fluctuations in the EC. Figure (109) shows the relationship between the EC and the Na-content. The relation between the EC and the Na follows the following

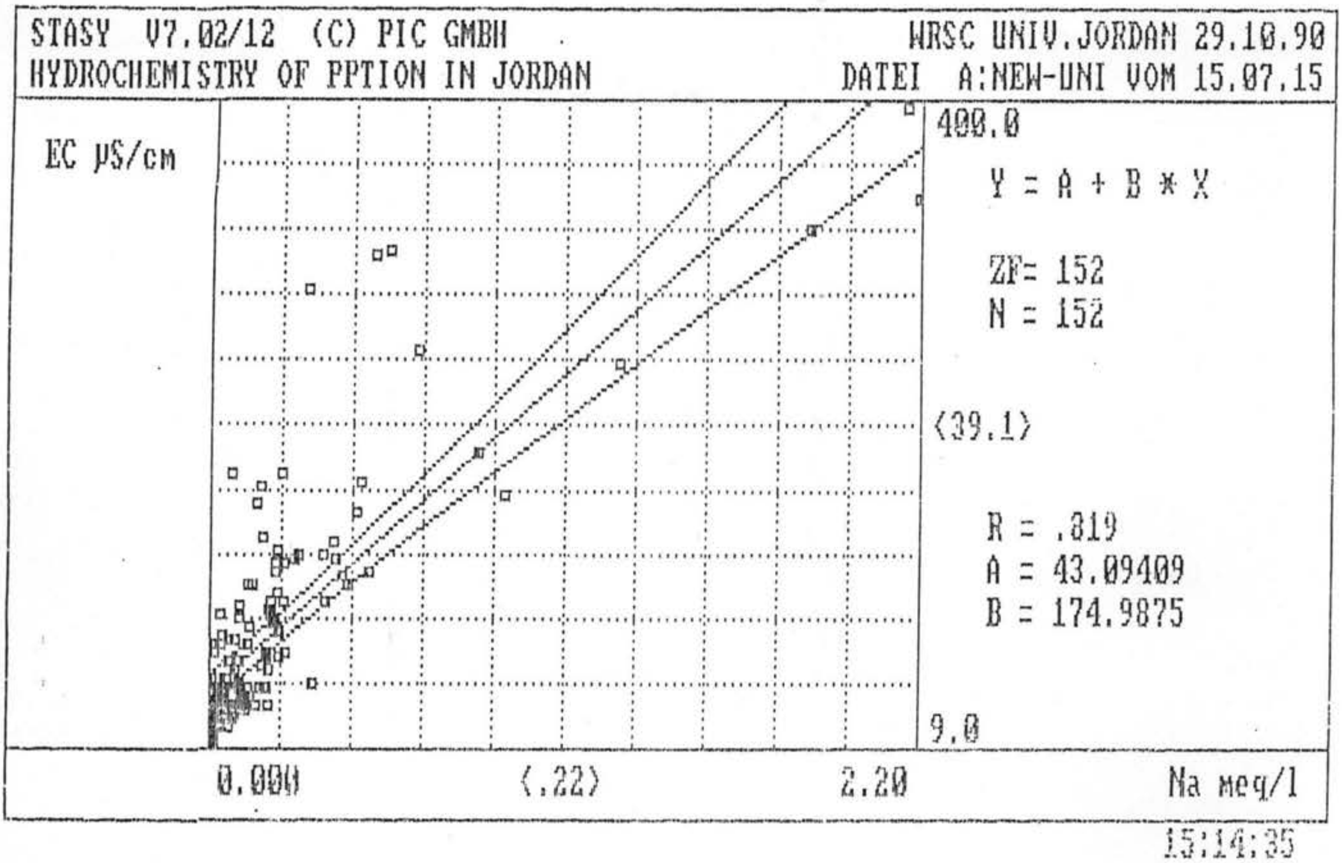
UNIVERSITY OF JORDAN PRECIPITATION
HYDROCHEMISTRY OF PRECIPITATION IN JORDAN
PRODUCT-MOMENT-CORRELATION (COEFF. / CASES / SIGNIFICANCE)

	QUAN T mm	TEMP ºC	pH-v alue	EC µS/cm	Na meq/1	K meq/1	Mg meq/1	Ca meq/1	Cl meq/1	NO3 meq/1	SO4 meq/1	HCO3 meq/	I mg/1	Br mg/1	F mg/1	PO4 mg/1	Li mg/1	TURB IDY	COLO R	Ag mg/1	Fe mg/1	Cu mg/1	Mn mg/1	Zn mg/1	Pb mg/1	Cr mg/1	Ni mg/1	
QUANT mm	1.000																											
	150																											
	0.000																											
TEMP ºC	-0.219	1.000																										
	145	147																										
	0.004	0.000																										
pH-value	-0.050	0.128	1.000																									
	150	147	152																									
	0.275	0.062	0.000																									
EC µS/cm	-0.152	0.309	0.189	1.000																								
	150	147	152	152																								
	0.030	0.000	0.007	0.000																								
Na meq/1	-0.111	0.225	0.097	0.819	1.000																							
	150	147	152	152	152																							
	0.088	0.002	0.210	0.000	0.000																							
K meq/1	-0.108	0.203	0.110	0.552	0.419	1.000																						
	150	147	152	152	152	152																						
	0.091	0.007	0.087	0.000	0.000	0.000																						
Mg meq/1	-0.090	0.174	0.208	0.567	0.545	0.484	1.000																					
	150	147	152	152	152	152	152																					
	0.137	0.018	0.005	0.000	0.000	0.000	0.000																					
Ca meq/1	-0.137	0.276	0.217	0.838	0.406	0.390	0.228	1.000																				
	150	147	152	152	152	152	152	152																				
	0.045	0.001	0.004	0.000	0.000	0.000	0.002	0.000																				
Cl meq/1	-0.152	0.287	0.108	0.900	0.853	0.478	0.888	0.821	1.000																			
	150	147	152	152	152	152	152	152	152																			
	0.030	0.001	0.091	0.000	0.000	0.000	0.000	0.000	0.000																			
NO3meq/1	-0.189	0.318	0.139	0.787	0.528	0.387	0.441	0.761	0.643	1.000																		
	150	147	152	152	152	152	152	152	152	152																		
	0.010	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000																		
SO4meq/1	-0.232	0.178	0.153	0.787	0.831	0.353	0.365	0.887	0.834	0.850	1.000																	
	150	147	152	152	152	152	152	152	152	152	152																	
	0.002	0.014	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000																	
HCO3meq/	-0.043	0.310	0.240	0.883	0.840	0.448	0.438	0.829	0.888	0.870	0.535	1.000																
	150	147	152	152	152	152	152	152	152	152	152	152																
	0.303	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000																
I mg/1	-0.153	0.201	0.154	0.151	0.171	0.153	0.138	0.054	0.185	0.223	0.357	-0.011	1.000															
	108	108	110	110	110	110	110	110	110	110	110	110	110															
	0.054	0.001	0.052	0.056	0.035	0.054	0.078	0.292	0.041	0.009	0.000	0.438	0.000															
Br mg/1	-0.160	0.057	-0.012	0.288	0.202	0.272	0.825	0.114	0.310	0.148	0.245	0.230	0.169	1.000														
	100	99	102	102	102	102	102	102	102	102	102	102	85	102														
	0.054	0.292	0.238	0.002	0.020	0.003	0.000	0.125	0.001	0.087	0.007	0.009	0.054	0.000														
F mg/1	-0.228	0.154	-0.098	0.263	0.244	0.072	0.180	0.202	0.245	0.252	0.200	0.230	0.088	0.038	1.000													
	73	71	75	75	75	75	75	75	75	75	75	75	65	68	75													
	0.028	0.099	0.205	0.010	0.018	0.273	0.058	0.039	0.018	0.014	0.041	0.023	0.230	0.221	0.000													
PO4 mg/1	-0.106	0.160	0.182	0.412	0.841	-0.009	0.178	0.395	0.389	0.309	0.100	0.360	-0.326	-0.116	0.120	1.000												
	68	67	70	70	70	70	70	70	70	70	70	70	55	38	51	70												
	0.197	0.097	0.064	0.000	0.002	0.449	0.088	0.001	0.001	0.004	0.087	0.001	0.007	0.191	0.203	0.000												
Li mg/1	-0.354	0.187	0.147	0.559	0.279	0.228	0.253	0.559	0.414	0.457	0.449	0.584	-0.044	0.307	0.535	0.248	1.000											
	78	75	78	78	78	78	78	78	78	78	78	78	61	38	50	64	78											
	0.001	0.052	0.098	0.000	0.007	0.022	0.012	0.000	0.000	0.000	0.000	0.000	0.387	0.010	0.000	0.023	0.000											
TURBIDY	-0.108	0.310	0.215	0.571	0.178	0.078	0.077	0.714	0.341	0.777	0.475	0.551	-0.014	-0.128	-0.016	0.383	0.438	1.000										
	69	67	70	70	70	70	70	70	70	70	70	70	53	48	42	56	70	70										
	0.190	0.005	0.035	0.000	0.070	0.284	0.268	0.000	0.002	0.000	0.000	0.000	0.442	0.178	0.442	0.003	0.000	0.000										
COLOR	-0.155	0.299	0.097	0.088	-0.039	0.184	0.738	0.094	0.008	0.088	0.107	0.052	0.305	0.269	0.015	-0.228	0.010	0.468	1.000									
	80	58	81	81	81	81	81	81	81	81	81	81	47	51	45	57	81	57	61									
	0.117	0.012	0.231	0.259	0.379	0.102	0.031	0.238	0.454	0.253	0.098	0.244	0.018	0.027	0.443	0.044	0.448	0.000	0.000									
Ag mg/1	0.138	-0.188	-0.277	-0.079	-0.046	-0.087	-0.083	-0.080	-0.080	-0.108	-0.072	-0.071	-0.042	0.038	-0.228	-0.361	-0.288	-0.144	-0.189	1.000								
	86	83	86	88	86	86	88	88	88	86	88	86	70	68	48	40	41	40	40	88								
	0.101	0.084	0.004	0.240	0.338	0.215	0.228	0.235	0.295	0.163	0.258	0.261	0.364	0.327	0.058	0.010	0.033	0.150	0.120	0.000								
Fe mg/1	0.172	-0.150	0.024	0.370	0.548	0.145	0.213	0.063	0.322	0.317	0.203	0.338	-0.145	0.038	0.239	0.435	0.300	0.139	-0.174	-0.088	1.000							
	89	87	69	89	69	89	69	69	69	69	69	69	58	54	43	34	34	31	31	54	69							
	0.078	0.112	0.414	0.001	0.000	0.118	0.038	0.308	0.004	0.004	0.045	0.002	0.143	0.345	0.059	0.005	0.038	0.141	0.178	0.315	0.000							
Cu mg/1	0.091	-0.145	-0.158	0.055	0.173	-0.045	-0.023	-0.084	0.001	0.011	0.007	0.123	-0.164	-0.038	0.022	0.372	-0.007	-0.061	-0.118	-0.085	0.377	1.000						
	69	87	89	69	69	89	69	69	69	69	69	65	58	54	43	34	34	31	31	54	65	65						
	0.233	0.120	0.097	0.325	0.075	0.357	0.418	0.303	0.470	0.445	0.454	0.159	0.088	0.387	0.431	0.014	0.461	0.370	0.268	0.324	0.001	0.000						
Mn mg/1	0.158	-0.099	-0.008	0.437	0.852	0.244	0.223	0.071	0.307	0.395	0.246	0.478	-0.134	0.083	0.047	0.335	0.202	0.098	-0.083	-0.045	0.885	0.362	1.000					
	69	87	69	69	69	69	69	69	69	69	65	65	58	54	43	34	34	31	31	54	65	65	83					
	0.098	0.215	0.240	0.000	0.000	0.021	0.032	0.283	0.005	0.001	0.020	0.000	0.163	0.278	0.380	0.023	0.125	0.303	0.329	0.381	0.000	0.001	0.000					
Zn mg/1	0.178	0.027	-0.109	-0.033	0.057	-0.033	0.014	-0.131	0.010	0.018	-0.047	-0.064	-0.135	-0.056	0.131	0.348	0.048	0.102	-0.064	-0.053	0.453	0.533	0.367	1.000				
	69	67	69	69	69	69	69	69	69	69	69	65	58	54	43	34	34	31	31	54	69	65	65	65				
	0.069	0.407	0.188	0.387	0.322	0.389	0.437	0.141	0.449	0.428	0.352	0.304	0.161	0.345	0.205	0.021	0.392	0.297	0.364	0.352	0.000	0.000	0.001	0.000				
Pb mg/1	0.185	-0.069	0.009	0.023	0.087	-0.075	0.084	-0.074	-0.037	0.083	-0.038	0.103	-0.190	-0.051	0.055	0.375	0.185	0.115	-0.132	-0.083	0.403	0.521	0.375	0.814	1.000			
	69	87	89	69	69	69	69	69	69	69	69	65	56	54	42	34	34	31	31	54	65	65	65	65	65			
	0.063	0.292	0.451	0.418	0.243	0.273	0.251	0.278	0.393	0.252	0.378	0.203	0.079	0.357	0.363	0.000	0.148	0.268	0.241	0.264	0.001	0.000	0.001	0.000	0.000			
Cr mg/1	-0.052	-0.029	0.069	-0.030	-0.007	-0.047	0.048	-0.067	-0.029	-0.028	-0.007	-0.028	-0.090	0.013	-0.084	0.237	-0.077	-0.117	-0.063	-0.047	0.109	0.111	0.058	0.091	0.176	1.000		
	69	87	69	69	69	69	69	69	69	69	65	65	58	54	43	34	34	31	31	54	65	65	65	65	65	65		
	0.337	0.401	0.290	0.398	0.456	0.350	0.349	0.297	0.399	0.403	0.455	0.403	0.257	0.444	0.300	0.087	0.335	0.268	0.331	0.366	0.198	0.184	0.327	0.232	0.072	0.000		
Ni mg/1	0.089	-0.098	0.184	0.357	0.485	0.140	0.276	0.097	0.279	0.243	0.108	0.400	-0.049	0.298	0.016	0.275	0.385	0.213	-0.005	-0.035	0.733	0.219	0.458	0.083	0.218	0.311	1.000	
	69	87	69	69	69	69	69	69	69	69	65	65	56	54	42	34	34	31	31	54	69	65	65	69	65	65	65	
	0.237	0.218	0.087	0.001	0.000	0.125	0.010	0.218	0.009	0.021	0.061	0.001	0.358	0.014	0.436	0.058	0.012	0.124	0.484	0.387	0.000	0.034	0.000	0.307	0.038	0.004	0.000	
Sr mg/1	-0.258	0.083	0.147	0.274	0.306	0.075	0.181	0.220	0.155	0.030	0.328	0.231	0.220	0.482	-0.108	0.000	9.999	9.999	9.999	-0.123	-0.043	0.074	0.484	-0.075	-0.127	0.000	-0.007	1.0
	33	33	33	33	33	33	33	33	33	33	33	33	28	24	12	5	3	1	1	21	33	33	33	33	33	33	33	
	0.074	0.382	0.210	0.060	0.040	0.341	0.157	0.108	0.197	0.422	0.030	0.098	0.140	0.008	0.388	0.500	9.999	9.999	9.999	0.300	0.400	0.342	0.002	0.430	0.244	0.500	0.460	0.0

Table(13): Product Moment Correlation for University of Jordan



Figure(108): Relationship between EC and HCO_3 for the University Station



Figure(109): Relationship between EC and Na for the University Station equations.

EC μs/cm = 43.09 + 175 [Na] meq/l,   r= 0.819

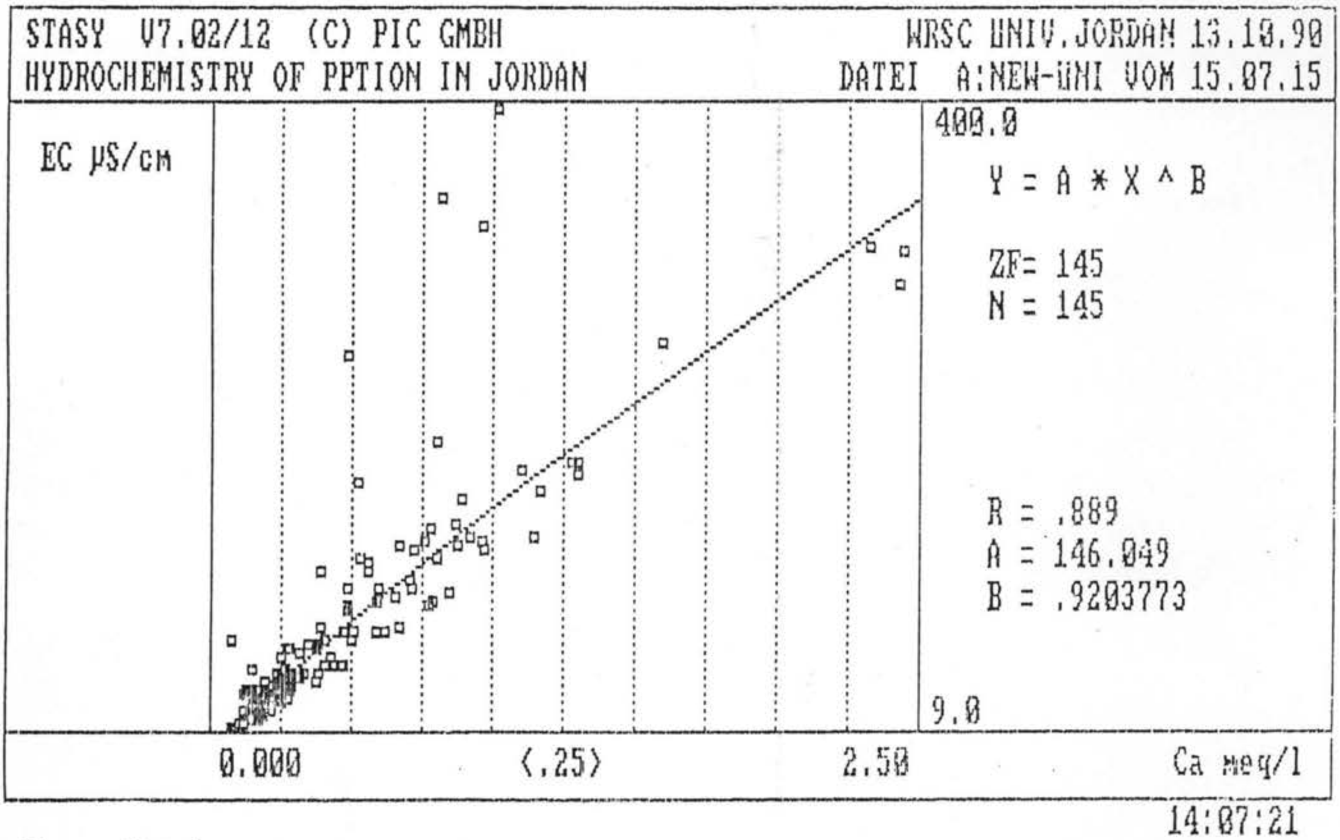
Samples with Na-concentrations of more than 0.70 meq/l are attributed to dusty atmosphere, where the increase in Na-contents is accompanied by an increase in the electric conductivity.

The dissolution processes of Ca containing minerals actually produced a gradual increase in the electrical conductivity as well as Ca (figure 110). Figure 110 shows the mathematical relationships between Ca and EC and the following equation represents this relation:-

Ec μs/cm = 148.3 + 0.914 [Ca]

with a correlation coefficient of 0.877. The circled samples in Figure 110 are characterized by an abrupt increase in the EC but a gradual increase in the calcium concentration. The explanation of this behavior is, that other soluble minerals are made responsible for the higher in crease in the EC than Ca, especially when Jordan was affected by Red Sea or Eastern depressions. The behavior of the other ions will be discussed later when considering the genesis of the whole chemical parameters of ppt. waters in Jordan using factorial analyses.

The analyses of 152 precipitation samples showed variations in the concentrations of the different parameters. The pH value of the water - in all composite samples - was above the biological pH value of 5.6. Only few outrain samples of heavy, long lasting rainfall and snow events of 2-3 days duration resulted in pH values of 4.7 and more. In general precipitation events started with pH values of less than 8.00 . This fact



Figure(110): Relationship between EC and Ca for the University Station indicates that although only light and medium types of industries are present in the city of Amman and although most houses use fuel oil to heat their homes during winter,no major effects of lowering the pH values of ppt. can be observed. This behaviour may have various reasons; the major one is the presence of dust in the atmosphere consisting of $CaCO_3$, $CaSO_4$, clays and other minerals that function as buffer for the acidity produced through the emission of CO_2, NO_x and SO_x gases into the atmosphere. A positive correlation between the pH values and the temperature of precipitation can be noticed. This fact is understandable because out rain is also positively correlated with temperature.

Although most buildings in Amman are recent (i.e. 80 % of which have been built within the past 25 years) yet there are older buildings and even very ancient ones like the Amphitheater or the Castle, but weathering seems to be minimal. Recent buildings although built of limestone not show any effects of chemical weathering.

North Jordan

Irbid Town and Weather Station

The interrelationships between the different measured parameters of ppt. water collected from Irbid town and the Weather station in the University of Science and Technology of Jordan will be discussed. The product moment correlations of the measured parameters of the two stations are presented in tables (14 and 15).

No serious differences between the constituents of rain water in the two stations are present as discussed before. Table (14),

GEO-500 V1.01/P2 (C) PIC GMBH
HYDROCHEMISTRY OF PPTION IN JORDAN
CORRELATION MATRIX

WRSC / UNIVERSITY OF JORDAN / AMMAN
IRBID TOWN STATION

	DATE	QUANT mm	pH VALUE	EC µS/cm	Na meq/1	K meq/1	Mg meq/1
DATE	1.0000						
QUANT mm	-0.2776	1.0000					
pH VALUE	-0.4177	0.3512	1.0000				
EC µS/cm	0.3712	-0.0483	-0.6941	1.0000			
Na meq/1	0.0239	0.1191	-0.4179	0.7060	1.0000		
K meq/1	0.3185	-0.1172	-0.2854	0.3461	-0.2841	1.0000	
Mg meq/1	0.5781	-0.2123	-0.7712	0.8165	0.6173	0.0406	1.0000
Ca meq/1	0.2738	-0.0036	-0.6209	0.9674	0.7677	0.1374	0.8104
C1 meq/1	-0.2530	-0.0078	-0.4732	0.6091	0.4291	0.3632	0.2013
NO3 meq/	0.2344	-0.1600	-0.6835	0.8331	0.8119	-0.0624	0.8250
SO4 meq/	0.4529	0.0190	-0.5720	0.9193	0.7736	0.0536	0.8769
HCO3 meq	0.3718	-0.1210	-0.7062	0.9354	0.4942	0.6194	0.6965

	Ca meq/1	C1 meq/1	NO3 meq/	SO4 meq/	HCO3 meq
Ca meq/1	1.0000				
C1 meq/1	0.5901	1.0000			
NO3 meq/	0.8680	0.5293	1.0000		
SO4 meq/	0.9463	0.3274	0.8331	1.0000	
HCO3 meq	0.8312	0.6466	0.6698	0.7425	1.0000

Table(14): Product Moment Correlation for Irbid Town Station

GEO-500 V1.01/P2 (C) PIC GMBH
HYDROCHEMISTRY OF PPTION IN JORDAN
CORRELATION MATRIX

WRSC / UNIVERSITY OF JORDAN / AMMAN
IRBID WEATHER STATION

	DATE	QUANT mm	pH VALUE	EC µS/cm	Na meq/1	K meq/1	Mg meq/1
DATE	1.0000						
QUANT mm	0.0888	1.0000					
pH VALUE	-0.7594	-0.1137	1.0000				
EC µS/cm	0.7866	-0.1273	-0.6248	1.0000			
Na meq/1	0.5244	-0.2579	-0.5568	0.6691	1.0000		
K meq/1	0.3937	-0.2366	-0.4071	0.7167	0.6932	1.0000	
Mg meq/1	0.8893	0.0902	-0.6751	0.8153	0.4788	0.2886	1.0000
Ca meq/1	0.6675	-0.0583	-0.4568	0.9097	0.3114	0.5839	0.7142
C1 meq/1	0.6869	-0.0158	-0.6791	0.7708	0.8590	0.5551	0.7219
NO3 meq/	0.2166	-0.2265	-0.3146	0.6911	0.3928	0.6851	0.2911
SO4 meq/	0.6653	-0.1534	-0.4461	0.8091	0.3313	0.5621	0.6557
HCO3 meq	0.6054	-0.1157	-0.4425	0.8849	0.5310	0.6376	0.6569

	Ca meq/1	C1 meq/1	NO3 meq/	SO4 meq/	HCO3 meq
Ca meq/1 3	1.0000				
C1 meq/1 3	0.4909	1.0000			
NO3 meq/ 3	0.7210	0.3739	1.0000		
SO4 meq/ 3	0.8535	0.3246	0.6218	1.0000	
HCO3 meq 3	0.8528	0.6853	0.6407	0.5503	1.0000

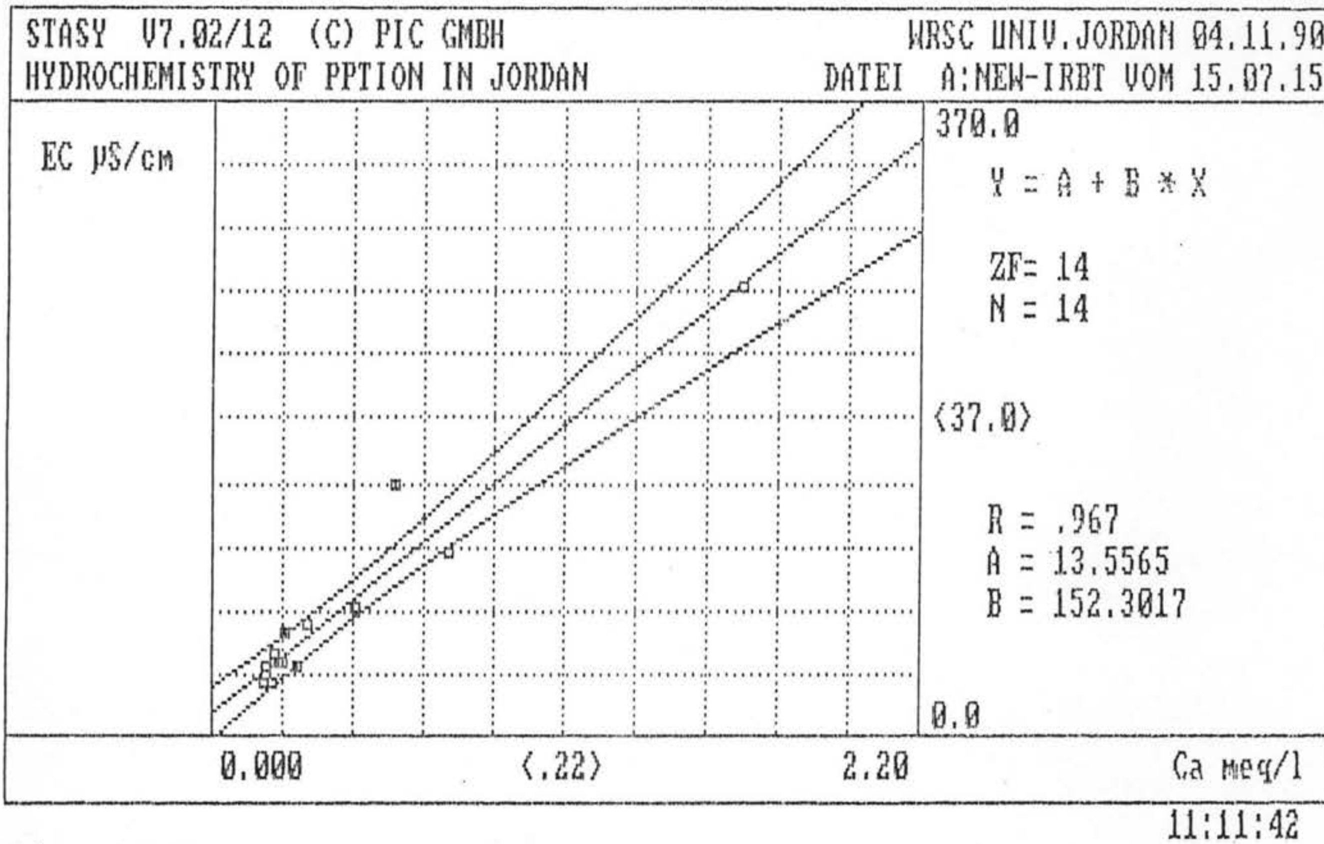
Table(15): Product Moment Correlation for Irbid Weather Station shows the matrix of correlation coefficients of the different constituents of rain water samples collected from Irbid town and table (15) shows that of the weather station.

From table (14), it can be seen that EC high significantly correlates with Ca, HCO_3, SO_4, NO_3, Mg, Na and Cl. with correlation coefficients of 0.967, 0.935, 0.919, 0.833, 0.817, 0.706 and 0.609 respectively some of these relations are represented in figures (111, 112, 113, 114, and 115). On the other hand, figure (116) shows the relationship between Na and Ca which are highly correlated, while table (15) shows that the EC significantly correlates with Ca, HCO_3, Mg, SO_4, Cl, K, NO_3 and Na with correlation coefficients of 0.910, 0.885, 0.815, 0.809, 0.771, 0.717, 0.691 and 0.669 respectively. Some of these relations are represented in figures (117,118, 119, 120, and 121) for the Irbid Weather station. Most of the constituents in rain water in the northern part of Jordan are affected by the origin of depression affecting Jordan, the type of dusty material in the khamasien winds and by thunderstorms and lightening which produce high nitrate content which correlates directly with the electrical conductivity.

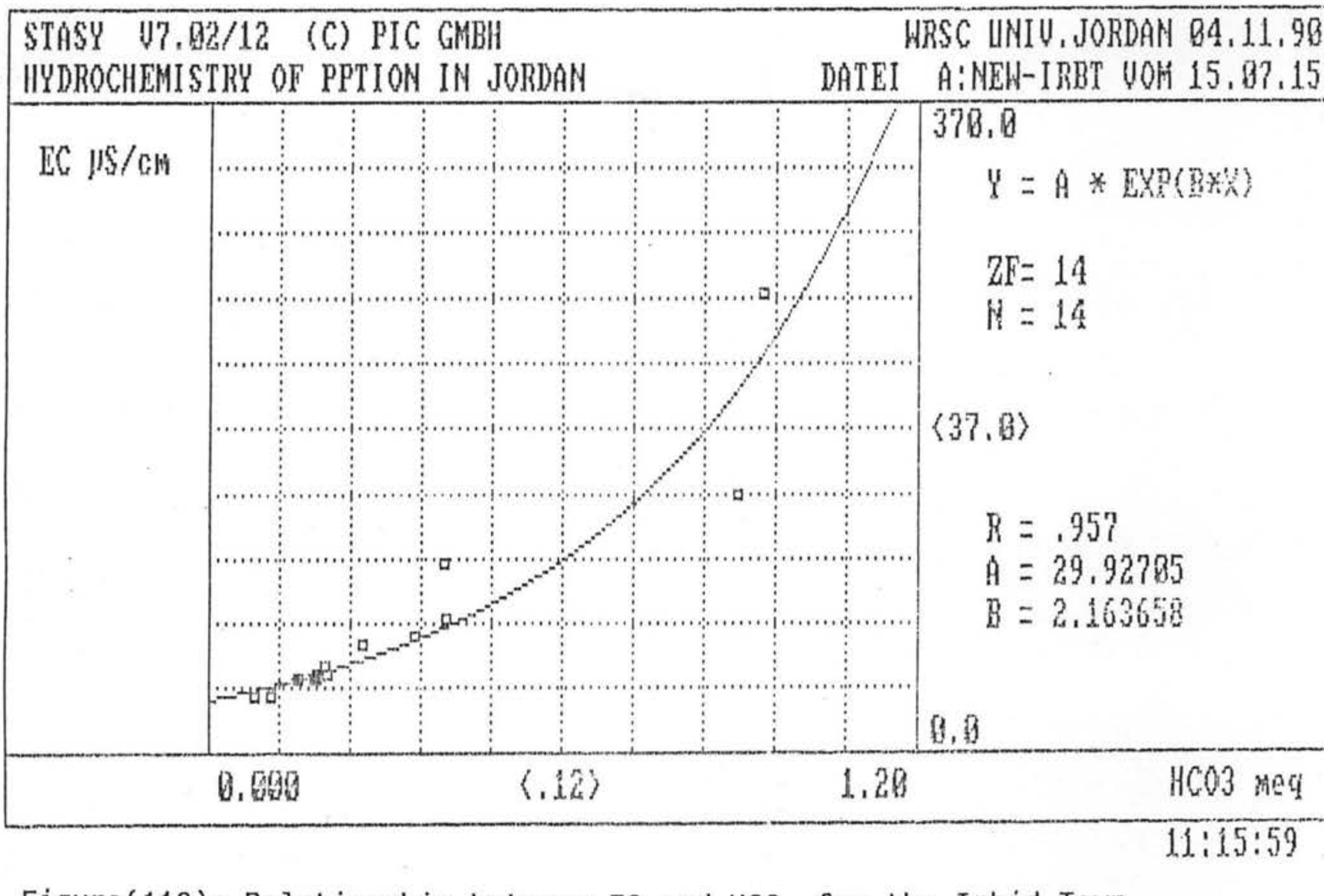
Eastern desert stations :

Khalidiya and Azraq stations :

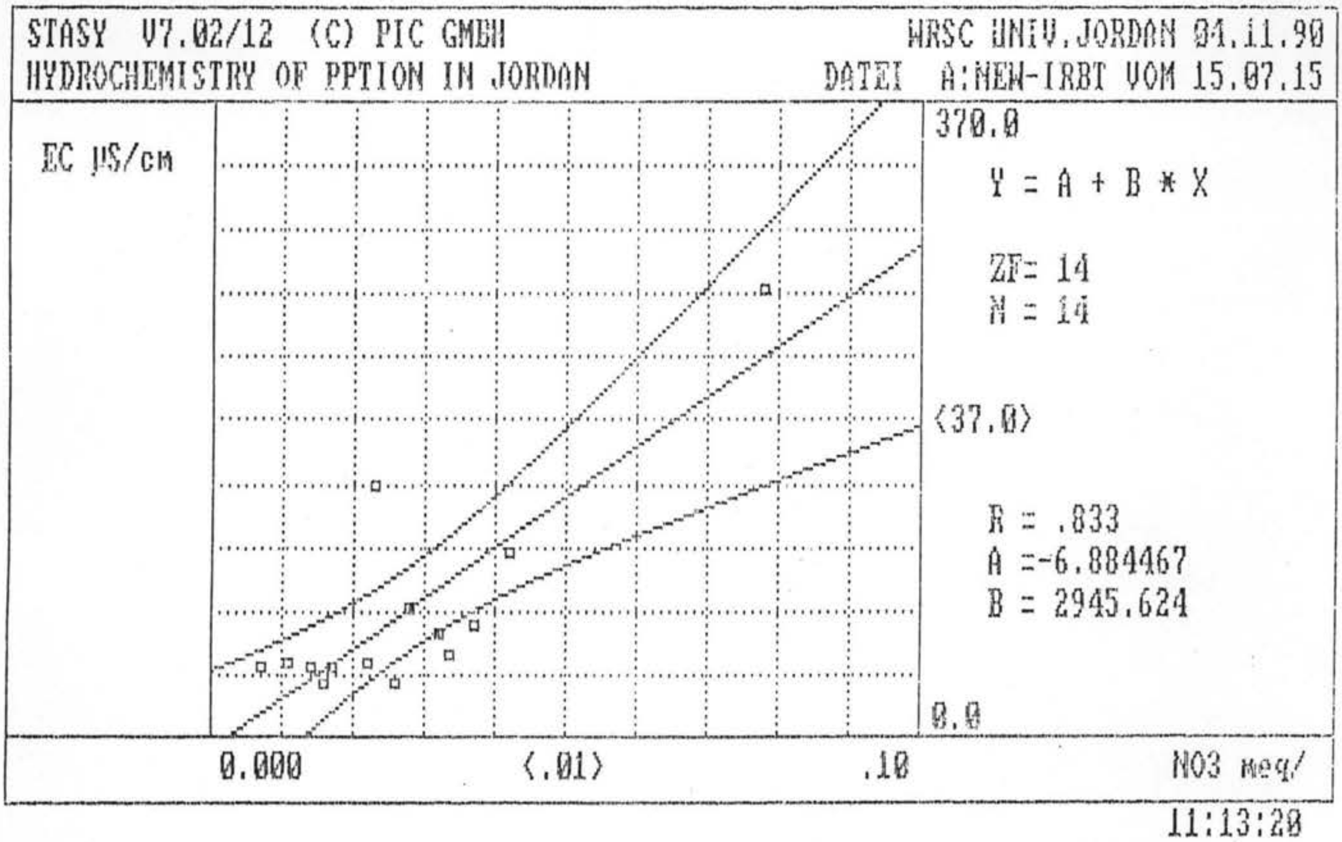
Two stations are considered to be typical for the eastern desert area, Khalidiya station and the Azraq station. The Khalidiya station is located at the transition zone between the 300 mm/a rainfall and the 200 mm/a isoline characterized by an intensive agricultural irrigated area; influenced by its topography by intense local dusty winds and by the saline soils



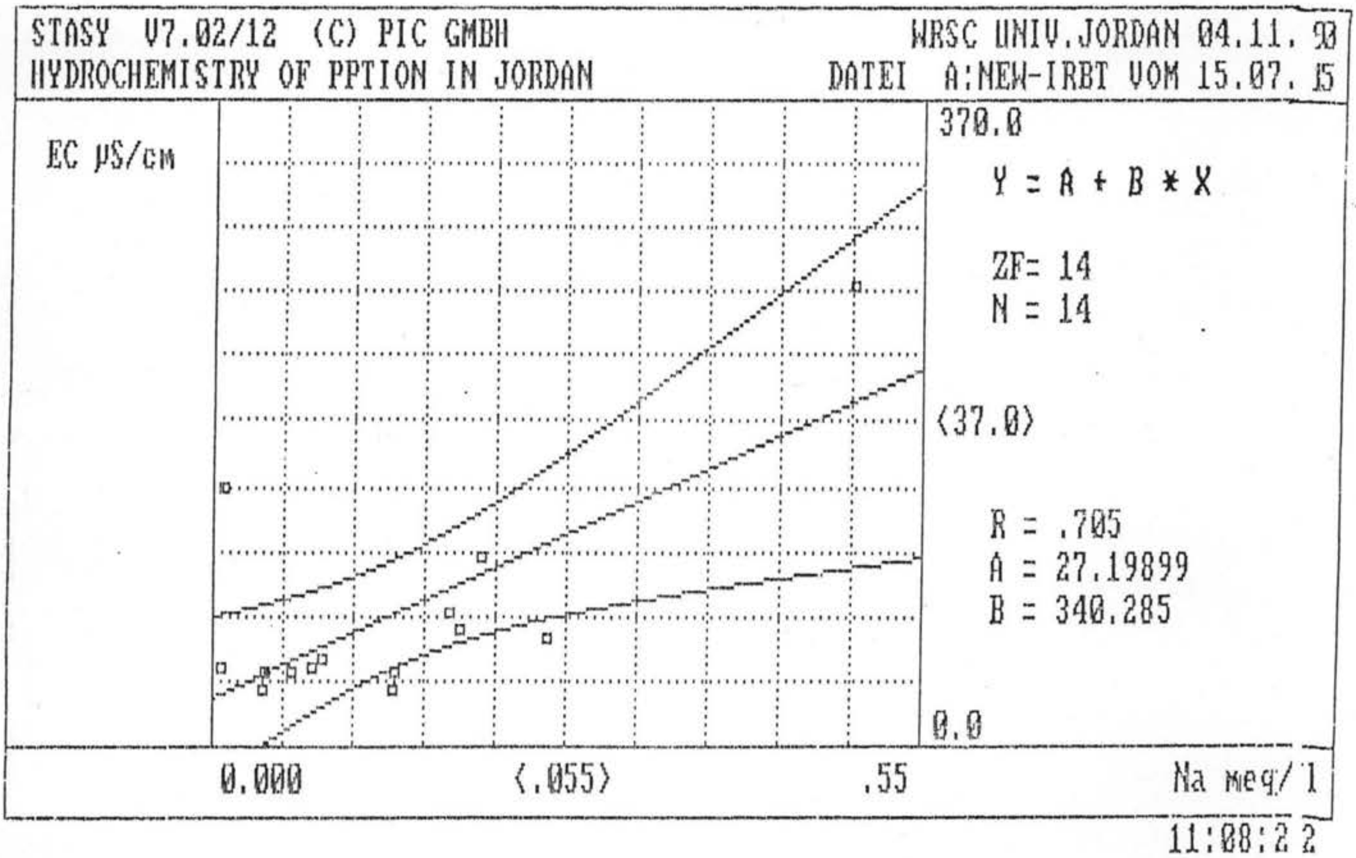
Figure(111): Relationship between EC and Ca for the Irbid Town Station



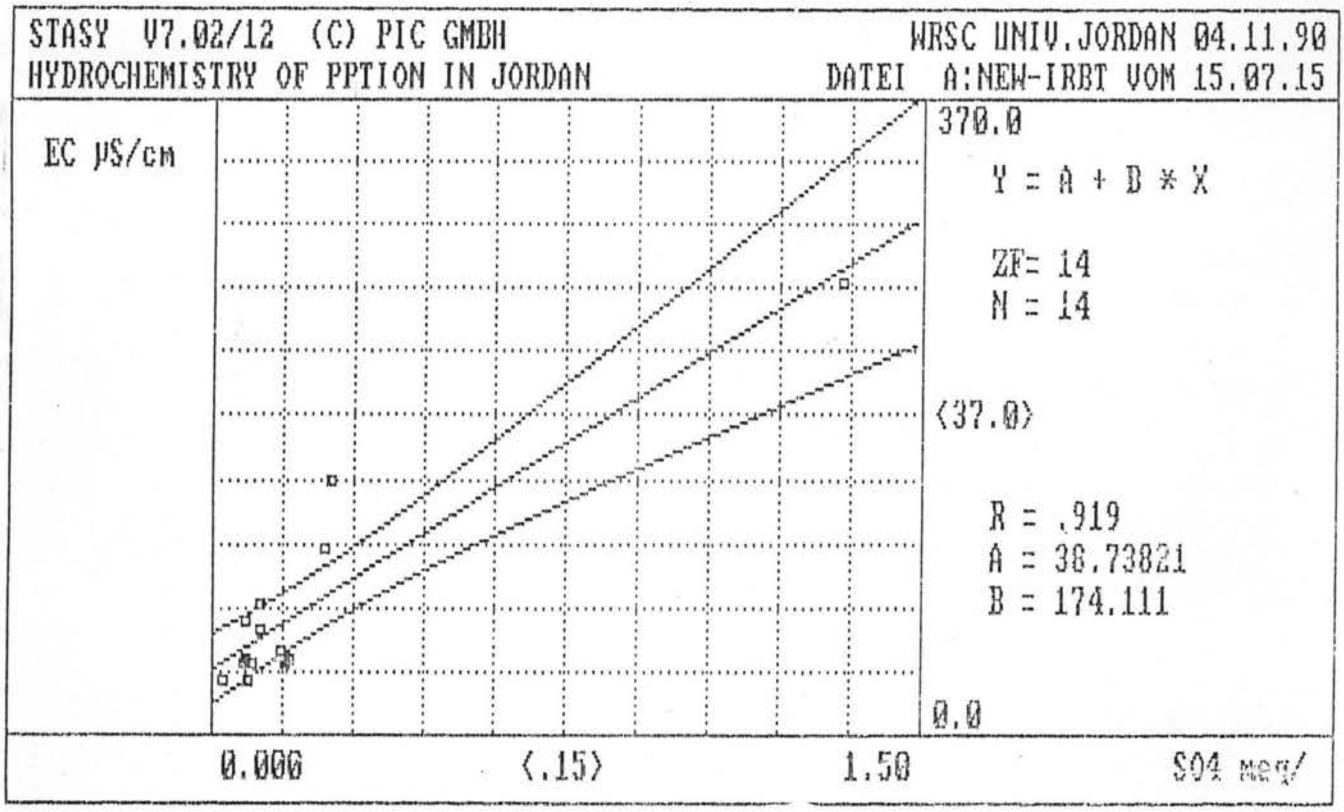
Figure(112): Relationship between EC and HCO_3 for the Irbid Town Station



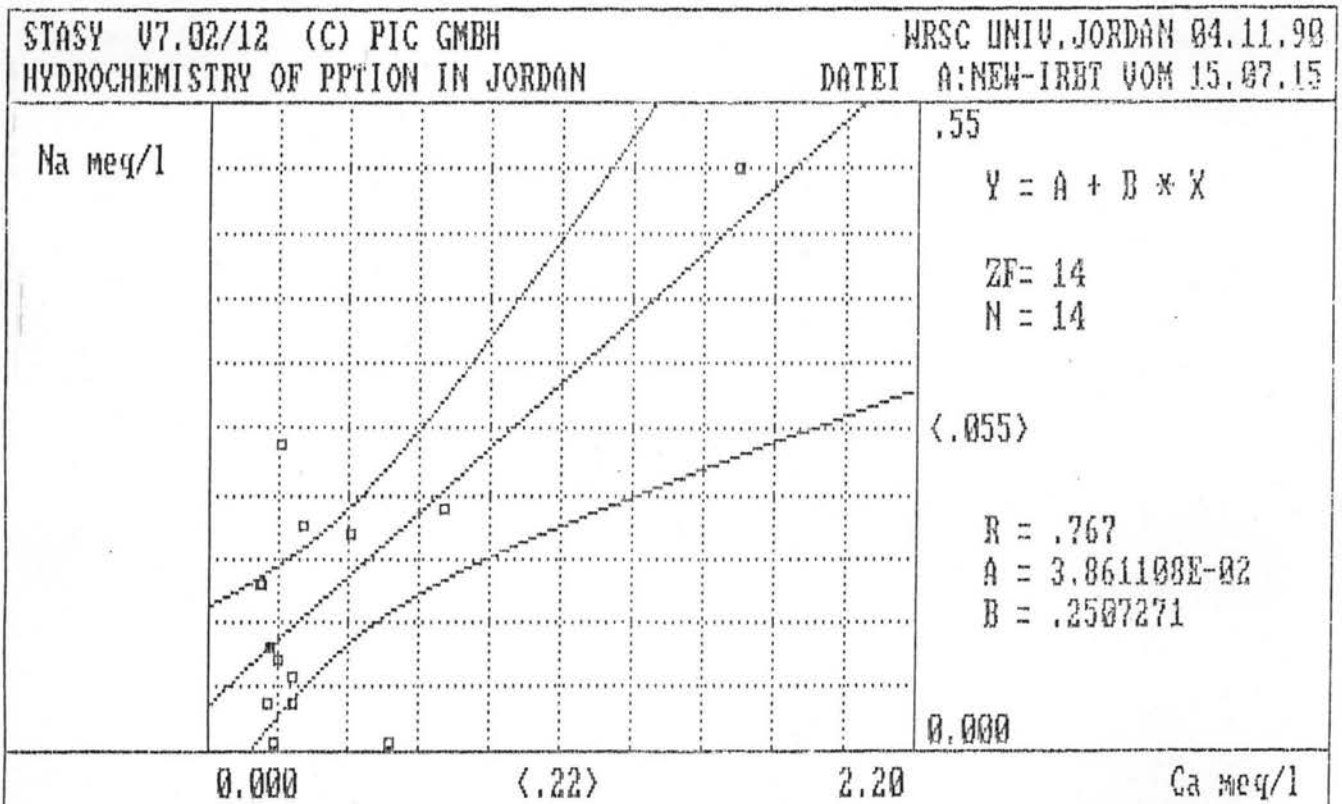
Figure(113): Relationship between EC and NO_3 for the Irbid Town Station



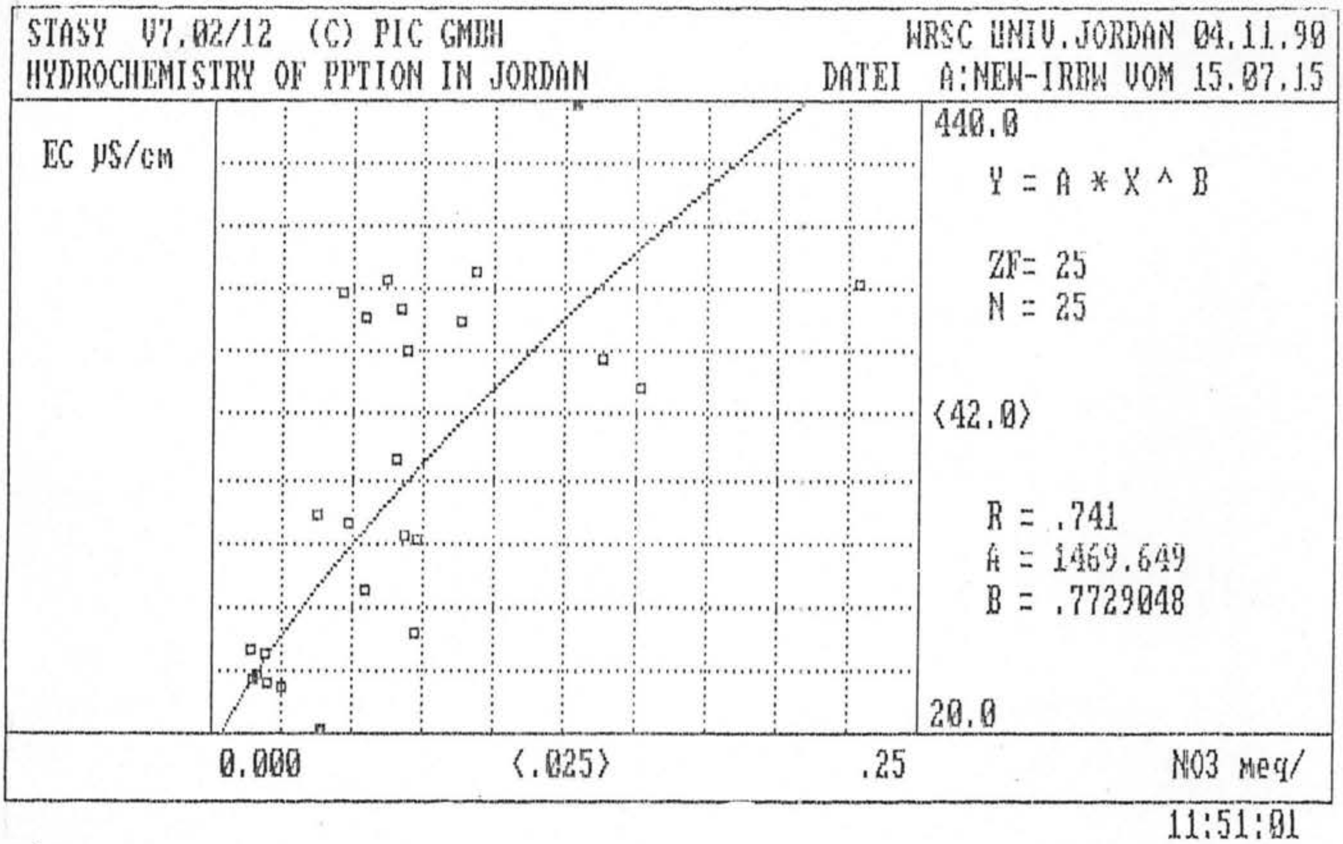
Figure(114): Relationship between EC and Na for the Irbid Town Station



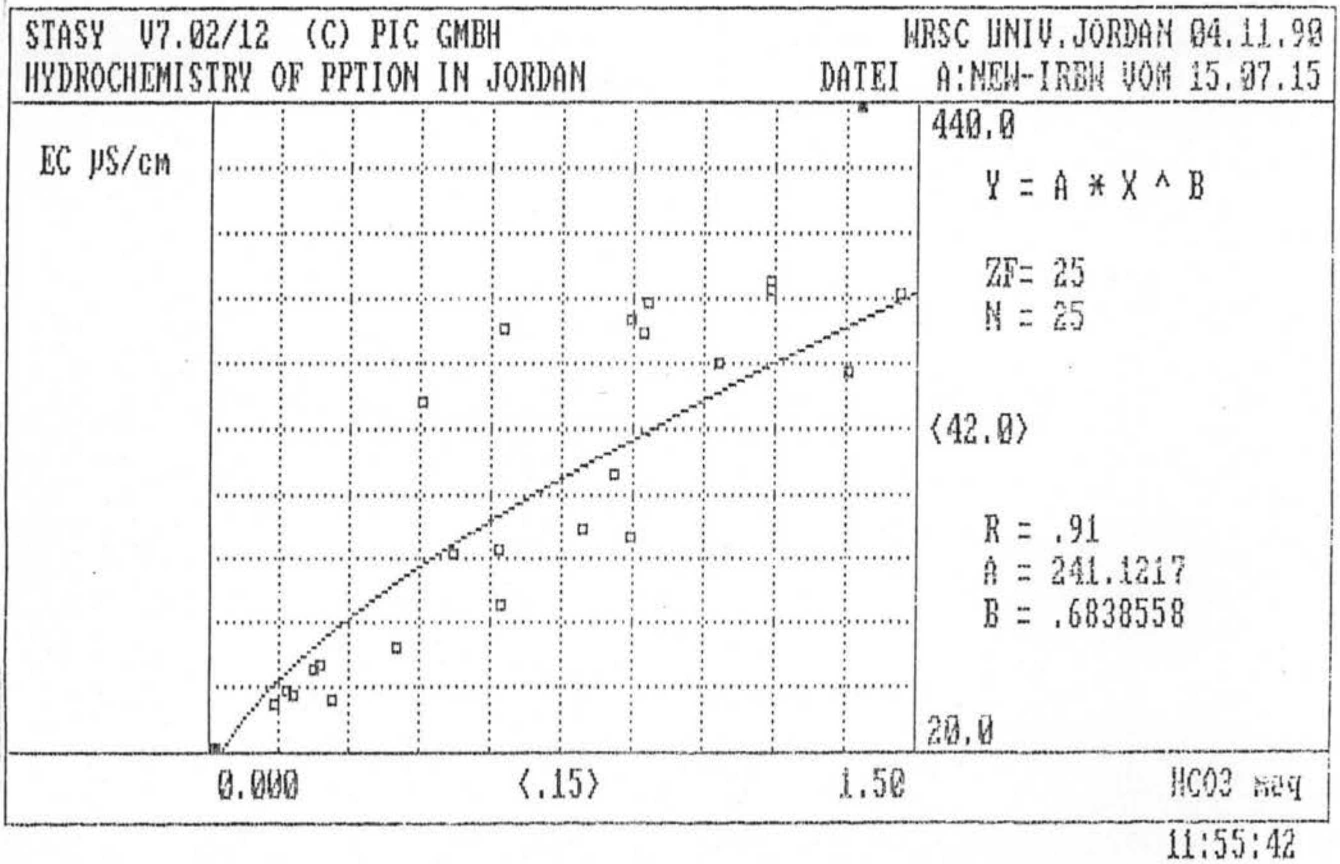
Figure(115): Relationship between EC and SO_4 for the Irbid Town Station



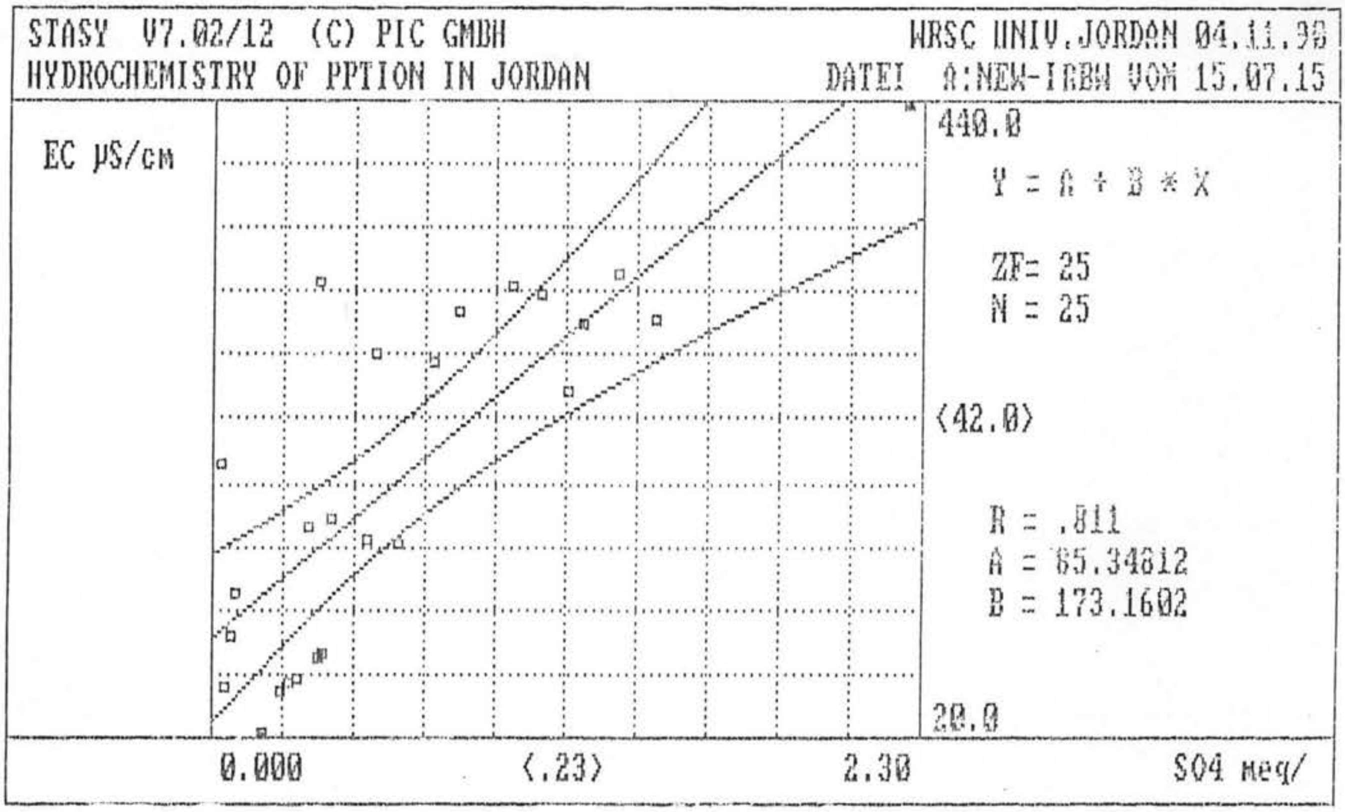
Figure(116): Relationship between Na and Ca for the Irbid Town Station



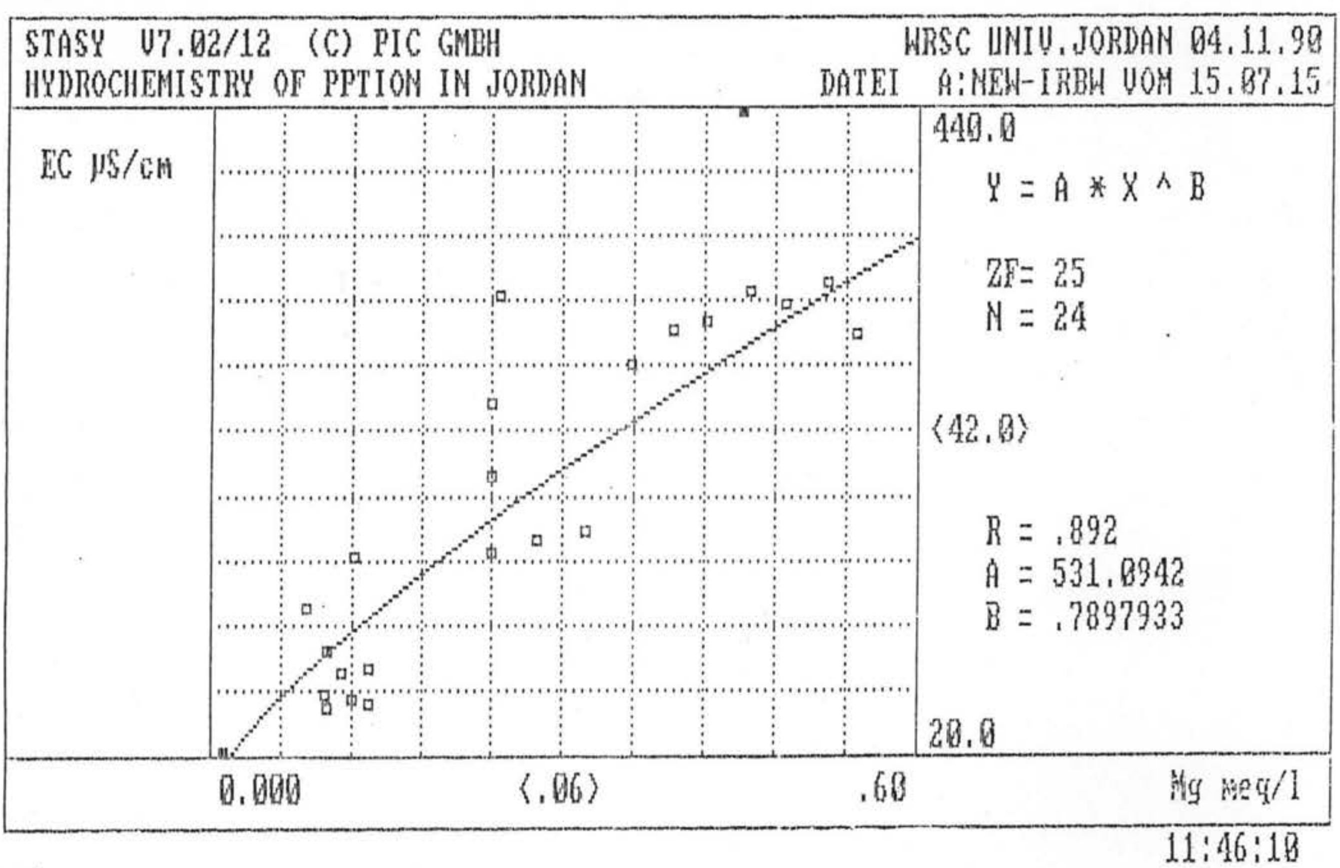
Figure(117): Relationship between EC and NO_3 for the Irbid Weather Station



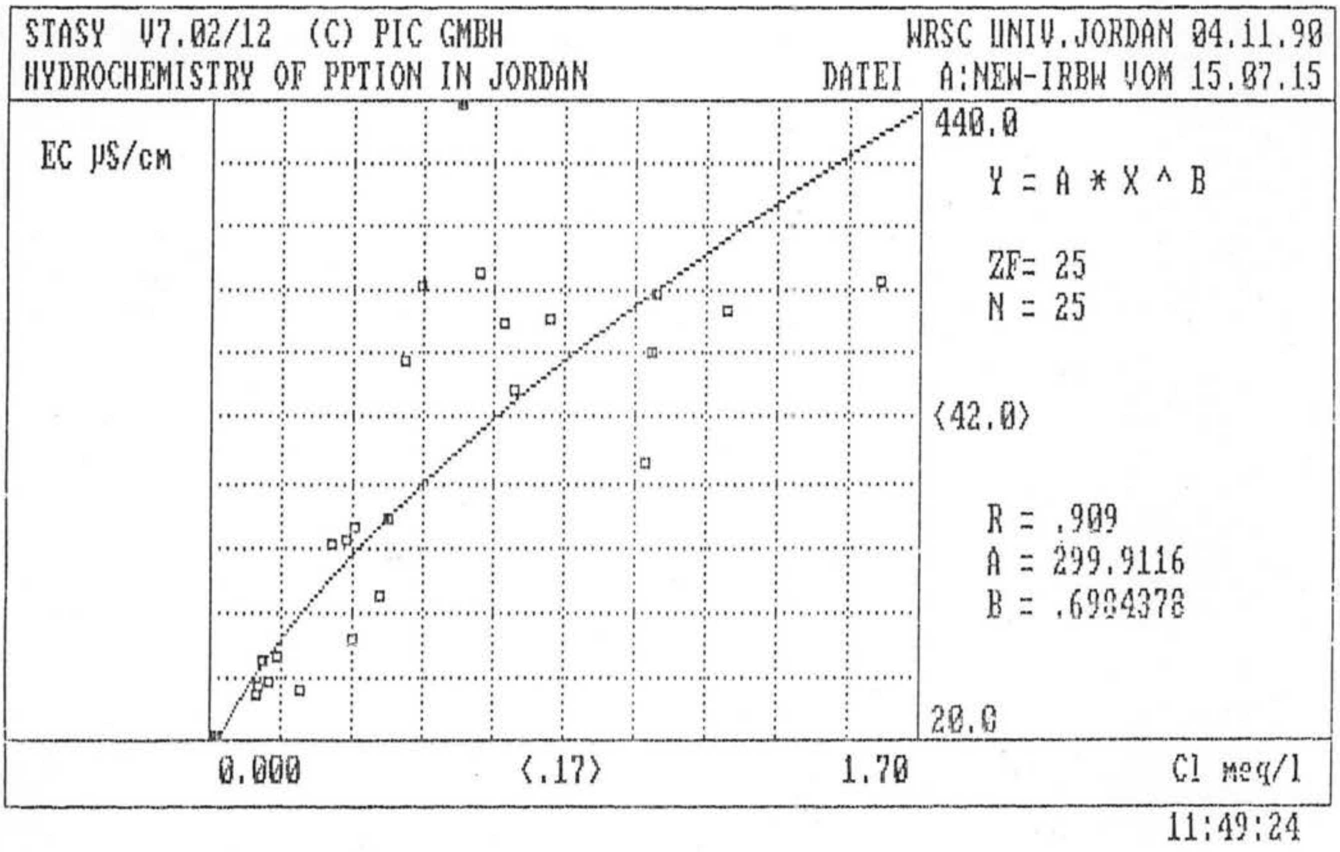
Figure(118): Relationship between EC and HCO_3 for the Irbid Weather Station



Figure(119): Relationship between EC and SO_3 for the Irbid Weather Station



Figure(120): Relationship between EC and Mg for the Irbid Weather Station



Figure(121): Relationship between EC and Cl for the Irbid Weather Station covering the area and originating from the weathering of the basalt plateau covering the eastern and north eastern part of Jordan as well as the Upper Cretaceous rocks.

The product moment correlation of the different constituents of both stations (Khalidiya and Azraq) are represented in tables (16 and 17), whereas the correlation products in table (16) are restricted to the major constituents. Table (17) (Azraq-station) includes both major and minor constituents.

Table (16) shows that the electrical conductivity of rain water samples directly and significantly correlate with Ca, HCO_3, SO_4, Mg, Cl, and Na and the correlation coefficients are 0.945, 0.817, 0.732, 0.712, 0.610, and 0.552 respectively. The relationship between EC and Ca-content is represented in figure (122) and it is found to fit the following equation.

EC us/cm = 20.53 + 120.84 [Ca meq/l].

This relation indicates a continuous dissolution of Ca-containing minerals from the dust especially the carbonate particles. The high EC values of rain water in this area are attributed to the acidification of rain water with the emission gases (CO_2, SO_x, NO_x) from the refinery to the west of Khalidiya.

Such an acidification process provided an excessive dissolution of most minerals constituting the dust in the area, and due to dissolution processes of carbonates, the pH value of water increased. On the other hand the bicarbonate content of rain water increases as the calcium and EC are increased. The EC-bicarbonate relationship is represented in figure (123) and is found to fit the following equation.

EC μs/cm = 184.20 + 0.632 [HCO_3 meq/l].

GEO-500 V1.01/P2 (C) PIC GMBH WRSC / UNIVERSITY OF JORDAN / AMMAN
HYDROCHEMISTRY OF PPTION IN JORDAN
CORRELATION MATRIX

	DATE	QUANT mm	pH VALUE	EC µS/cm	Na meq/l	K meq/l	Mg meq/l
DATE	1.0000						
QUANT mm	-0.1337	1.0000					
pH VALUE	-0.2504	0.0240	1.0000				
EC µS/cm	0.3645	-0.1827	-0.0981	1.0000			
Na meq/l	0.2272	0.0305	-0.0391	0.4627	1.0000		
K meq/l	-0.0218	0.0718	-0.1795	0.5521	0.4321	1.0000	
Mg meq/l	0.2005	0.0608	-0.1247	0.7117	0.3882	0.3589	1.0000
Ca meq/l	0.3583	-0.2617	-0.0734	0.9452	0.1900	0.4347	0.5411
Cl meq/l	0.3869	-0.0569	-0.0903	0.6104	0.7484	0.2860	0.6244
NO3 meq/	-0.0716	-0.2349	-0.0795	0.3568	0.1846	0.2654	0.2382
SO4 meq/	0.1803	-0.1224	-0.1924	0.7318	0.2333	0.3987	0.6015
HCO3 meq	0.2983	-0.1581	0.0098	0.8171	0.2167	0.4687	0.4479

	Ca meq/l	Cl meq/l	NO3 meq/	SO4 meq/	HCO3 meq
Ca meq/l	1.0000				
Cl meq/l	0.4033	1.0000			
NO3 meq/	0.3306	0.1452	1.0000		
SO4 meq/	0.7028	0.4656	0.3968	1.0000	
HCO3 meq	0.8485	0.2028	0.1268	0.3026	1.0000

Table(16): Product Moment Correlation for Khalidiya Station

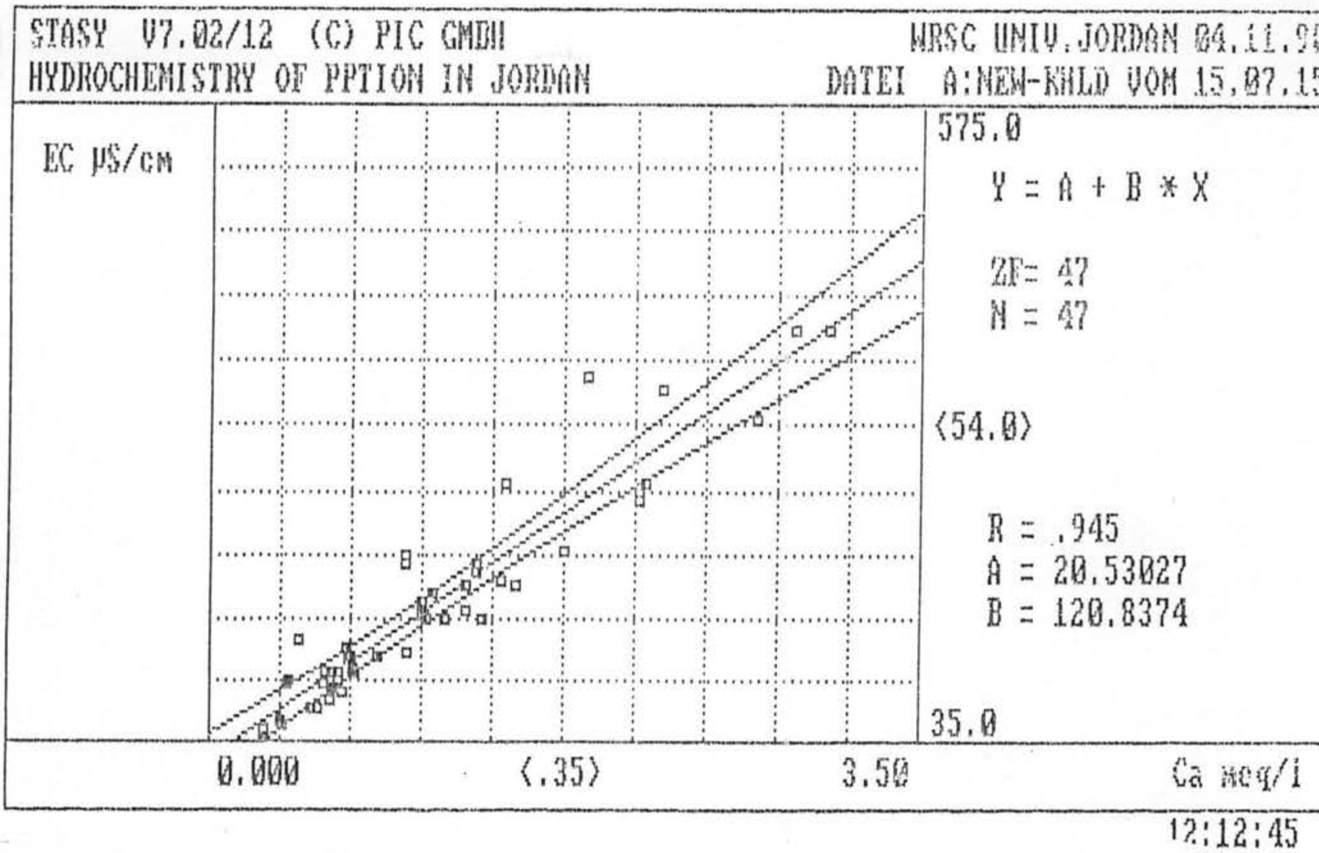
GEO-500 V1.01/P2 (C) PIC GMBH WRSC / UNIVERSITY OF JORDAN / AMMAN
HYDROCHEMISTRY OF PPTION IN JORDAN AZRAQ STATION
CORRELATION MATRIX

	DATE	QUANT mm	TEMP °C	pH VALUE	EC µS/cm	Na meq/l	K meq/l
DATE	1.0000						
QUANT mm	-0.0335	1.0000					
TEMP °C	-0.2420	0.3314	1.0000				
pH VALUE	0.1889	0.3856	0.6717	1.0000			
EC µS/cm	0.7500	0.0650	0.1570	0.4920	1.0000		
Na meq/l	0.3543	-0.0694	0.2035	0.3105	0.7358	1.0000	
K meq/l	0.4080	0.2728	0.3166	0.4769	0.7948	0.7508	1.0000
Mg meq/l	0.7272	-0.0130	0.0192	0.3323	0.7889	0.5699	0.5779
Ca meq/l	0.7264	0.1449	0.1194	0.4808	0.8740	0.3629	0.5988
Cl meq/l	0.5429	-0.2518	-0.0083	0.1511	0.8161	0.8791	0.6663
NO3 meq/	0.6433	-0.2923	0.0313	0.2771	0.6903	0.4047	0.3108
SO4 meq/	0.5525	0.0521	0.3578	0.4893	0.7828	0.3605	0.7062
HCO3 meq	0.6827	0.2961	0.0390	0.5009	0.8207	0.5914	0.5905
I mg/l	-0.4281	-0.3069	-0.0597	-0.0155	-0.3831	-0.3921	-0.3671
Br mg/l	-0.1886	-0.1274	-0.2285	-0.3442	-0.0467	0.0148	-0.1429
F mg/l	0.6540	0.2805	-0.0959	0.3411	0.7582	0.5474	0.6255
PO4 mg/l	0.4196	-0.2222	0.2154	0.3345	0.4176	-0.0327	0.0642
Li mg/l	0.3989	-0.2179	0.0656	0.1616	0.4889	0.1813	0.2485
TURBIDY	-0.1001	0.2107	0.2682	0.3807	0.0993	0.1664	-0.0148

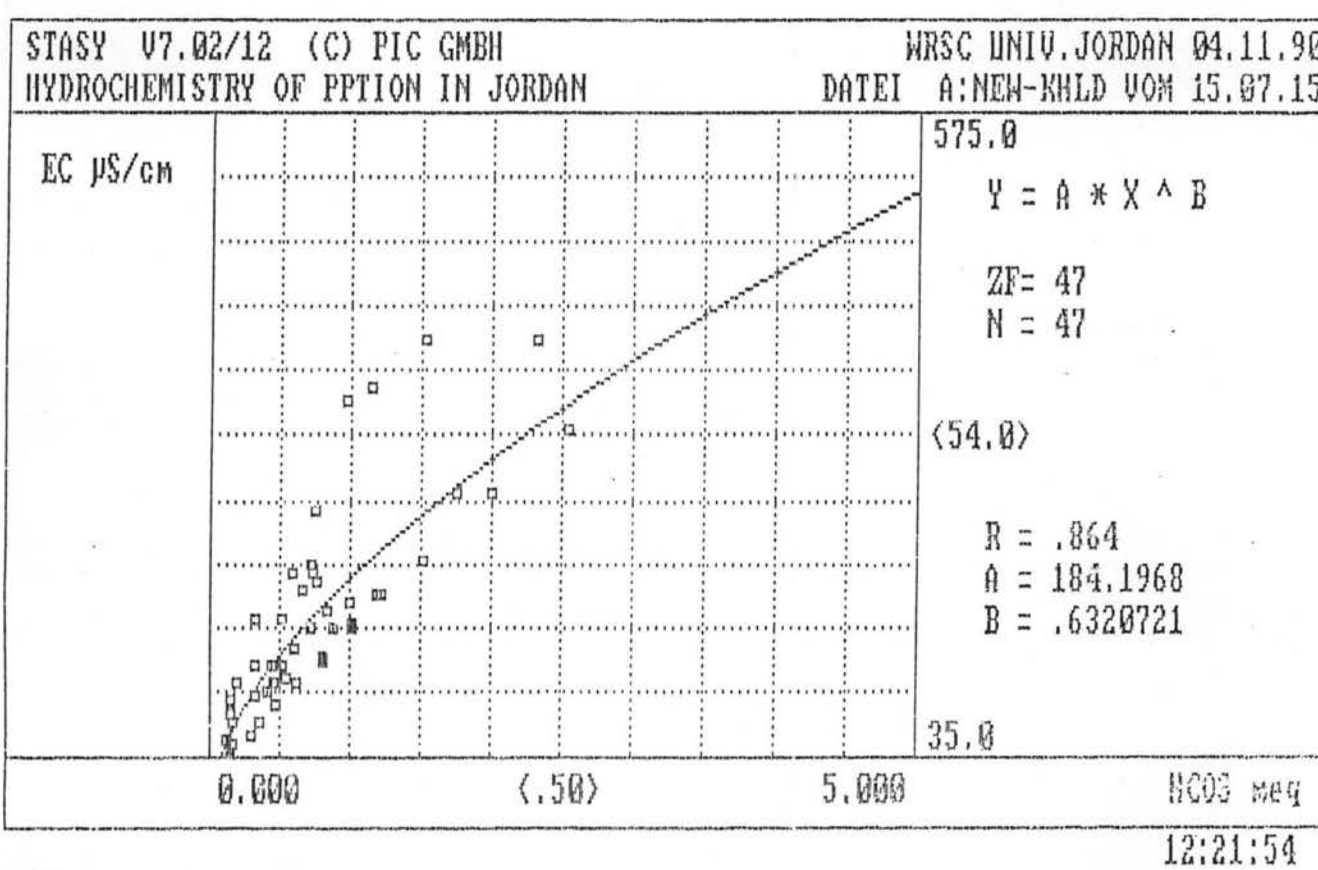
	Mg meq/l	Ca meq/l	Cl meq/l	NO3 meq/	SO4 meq/	HCO3 meq	I mg/l
Mg meq/l	1.0000						
Ca meq/l	0.5401	1.0000					
Cl meq/l	0.6383	0.5464	1.0000				
NO3 meq/	0.4413	0.7194	0.6620	1.0000			
SO4 meq/	0.5681	0.8315	0.5274	0.6363	1.0000		
HCO3 meq	0.7005	0.7054	0.5164	0.3750	0.3962	1.0000	
I mg/l	-0.2356	-0.2933	-0.2980	-0.1154	-0.1277	-0.4782	1.0000
Br mg/l	-0.1374	-0.0239	0.2655	0.0983	-0.1165	-0.1987	0.0299
F mg/l	0.5524	0.6871	0.5187	0.3683	0.4585	0.8168	-0.4103
PO4 mg/l	0.3511	0.5732	0.2496	0.6814	0.6084	0.1442	0.0899
Li mg/l	0.6394	0.4353	0.3926	0.4126	0.5213	0.2860	0.1249
TURBIDY	-0.2672	0.1789	0.0698	0.0966	-0.0608	0.2007	-0.0355

	Br mg/l	F mg/l	PO4 mg/l	Li mg/l	TURBIDY
Br mg/l	1.0000				
F mg/l	-0.1653	1.0000			
PO4 mg/l	0.0800	-0.0319	1.0000		
Li mg/l	0.0529	0.0588	0.5482	1.0000	
TURBIDY	0.0952	0.2892	0.0753	-0.4005	1.0000

Table(17): Product Moment Correlation for Azraq Station



Figure(122): Relationship between EC and Ca for Khalidiya Station



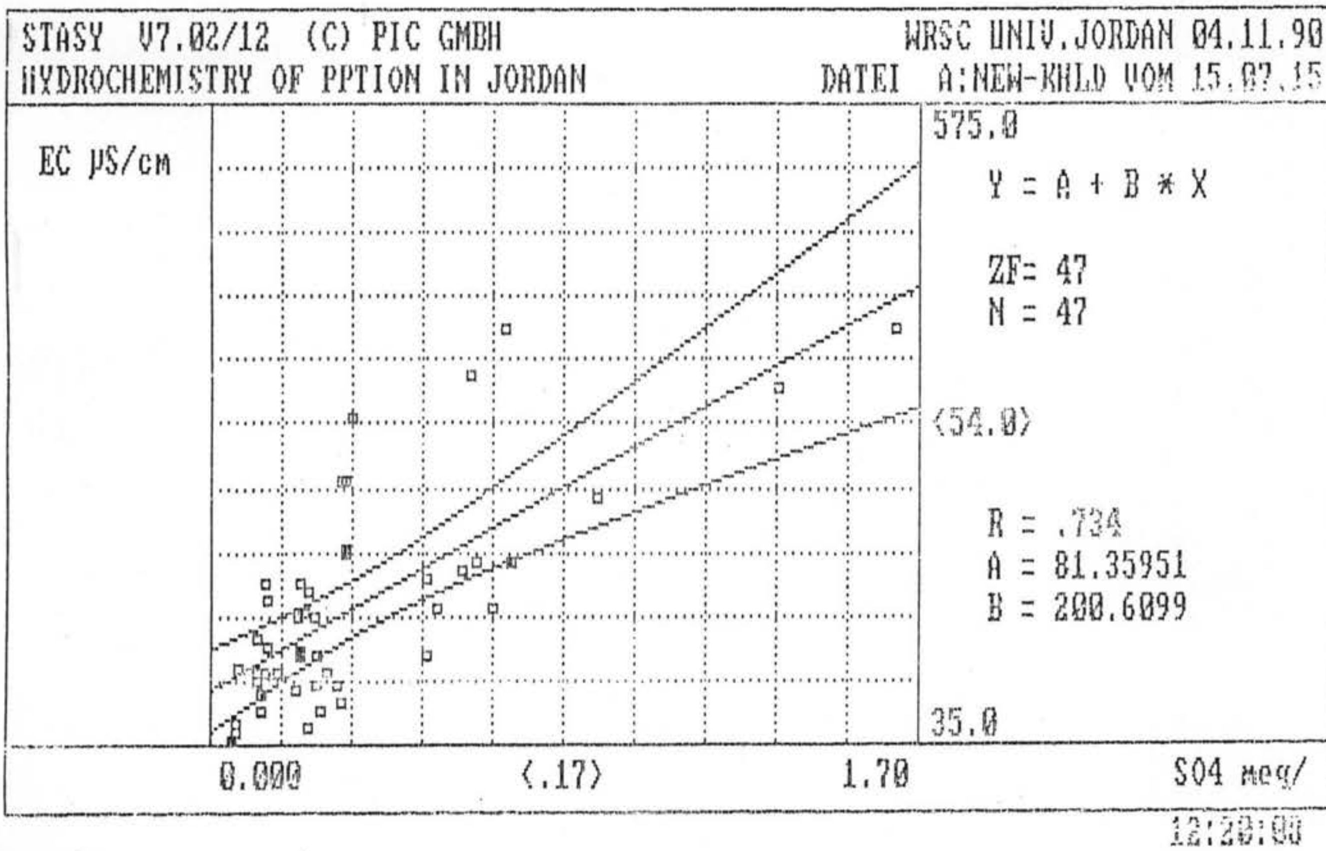
Figure(123): Relationship between EC and HCO_3 for Khalidiya Station

The other main source of calcium in rain water is the dissolution of gypsum particles in the atmosphere, but if the content of sulfate which reached a concentration of about 1.7 meq/l was due to the dissolution of gypsum, then the produced calcium from this process will be 1.7 meq/l. On the other hand the maximum bicarbonate content was about 2.5 meq/l. Due to the dissolution of Ca-Carbonate mineral $CaCO_3$, for every 1 meq/l Ca two meq/l of bicarbonates will be produced, then by the presence of 1.7 meq/l bicarbonate a calcium content of about 0.85 meq/l will be produced. The present concentration of Ca, HCO_3, and sulfates in rain water samples were not in full agreement with each other due to those other sources of Ca present in the area. These sources are Ca-phosphate, calcium chloride and dolomite which are present in the atmospheric dust of the area.

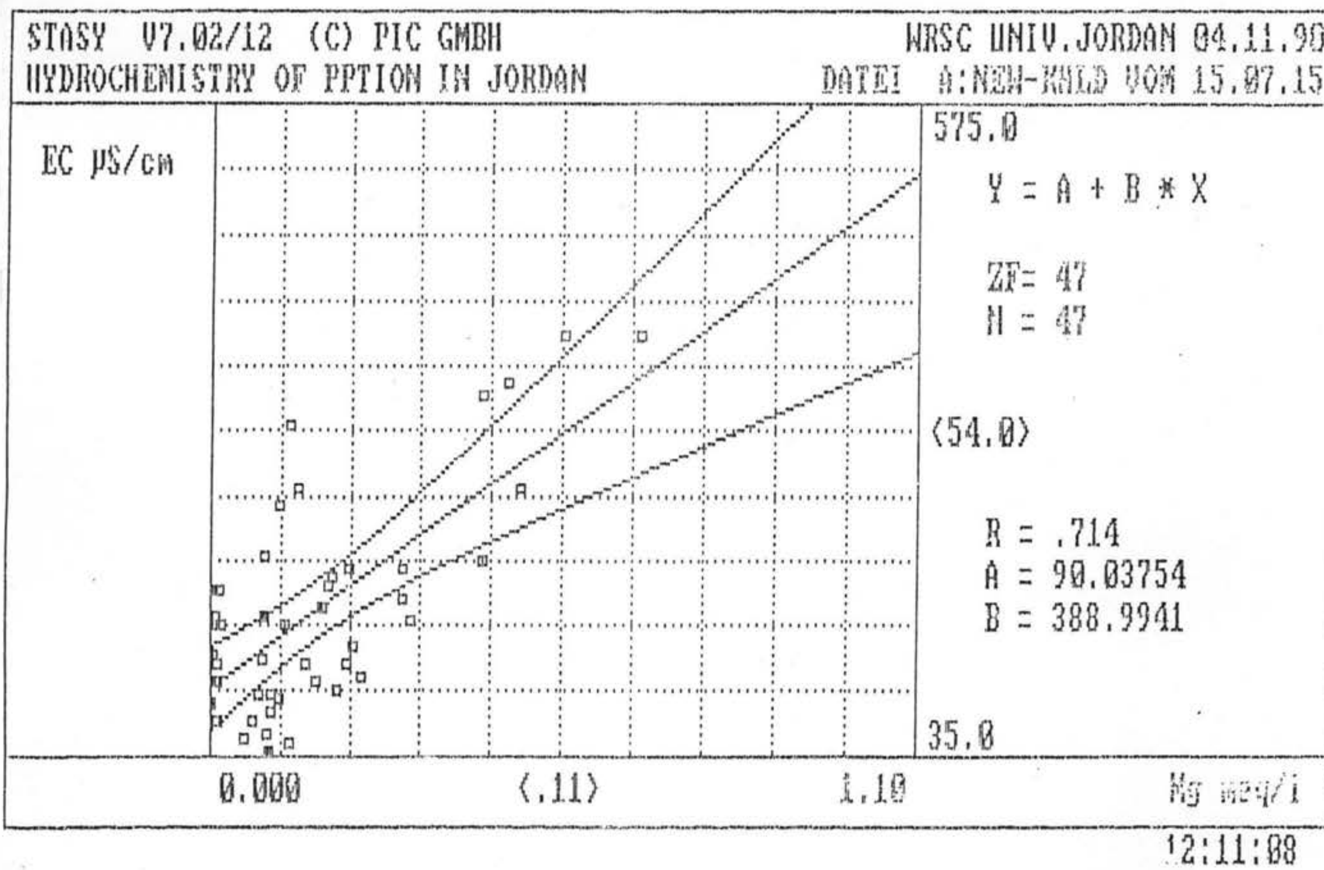
The relationship between EC with sulfate and Mg are shown in figures (124 and 125) and the relation between Ca with HCO_3 and SO_4 are shown in figures (126 and 127).

__Ruseifeh__ __Station__ __:__

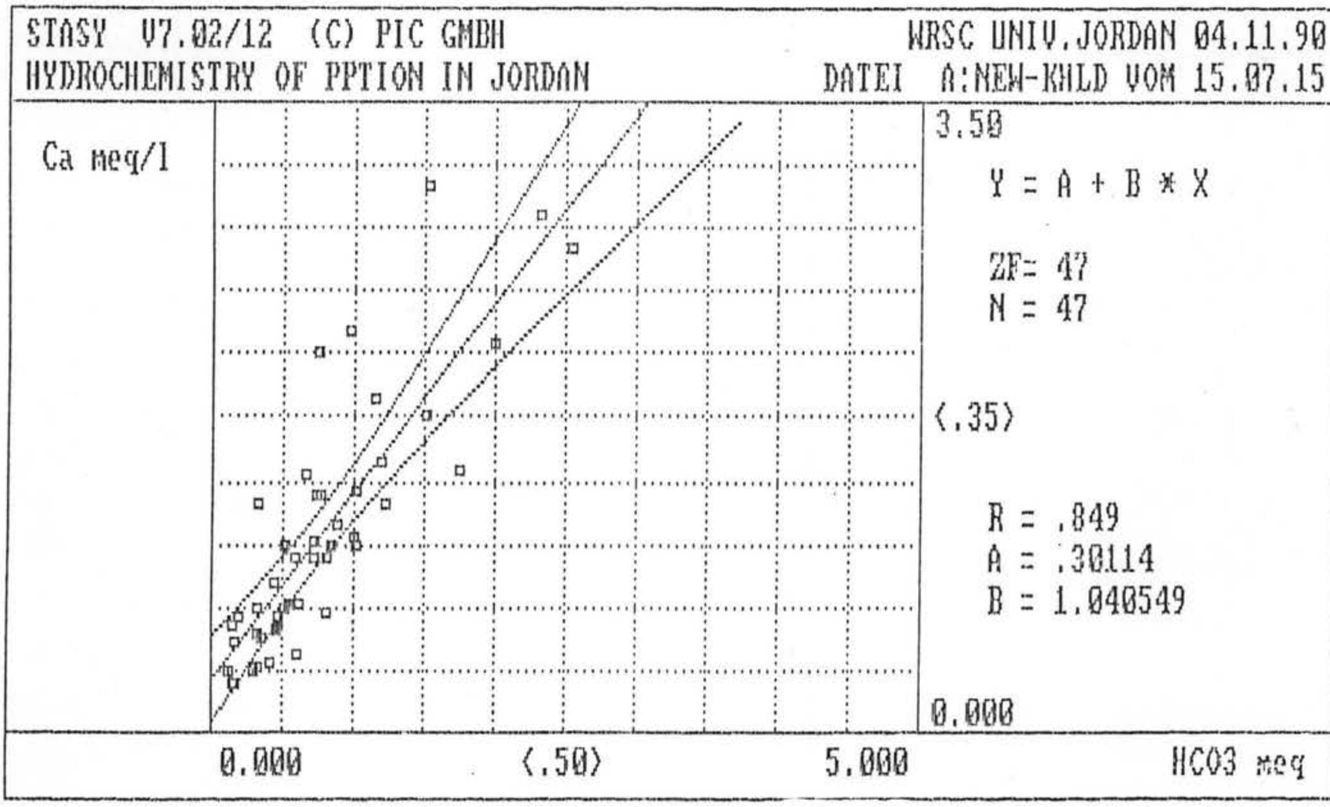
The product moment correlation between the different measured parameters of rain water samples collected from Ruseifeh station is shown in table (18). The Ruseifeh city is bordered at its western and southern parts by the phosphate mines and the larger part of the city was constructed on phosphatic rocks. The phosphate deposits were mined in the past by tunnels, but in the period between 1968 and mid eighties open pit mining was the only method to mine the phosphate ores. Ruseifeh phosphate mines are not in operation since mid eighties but there are still



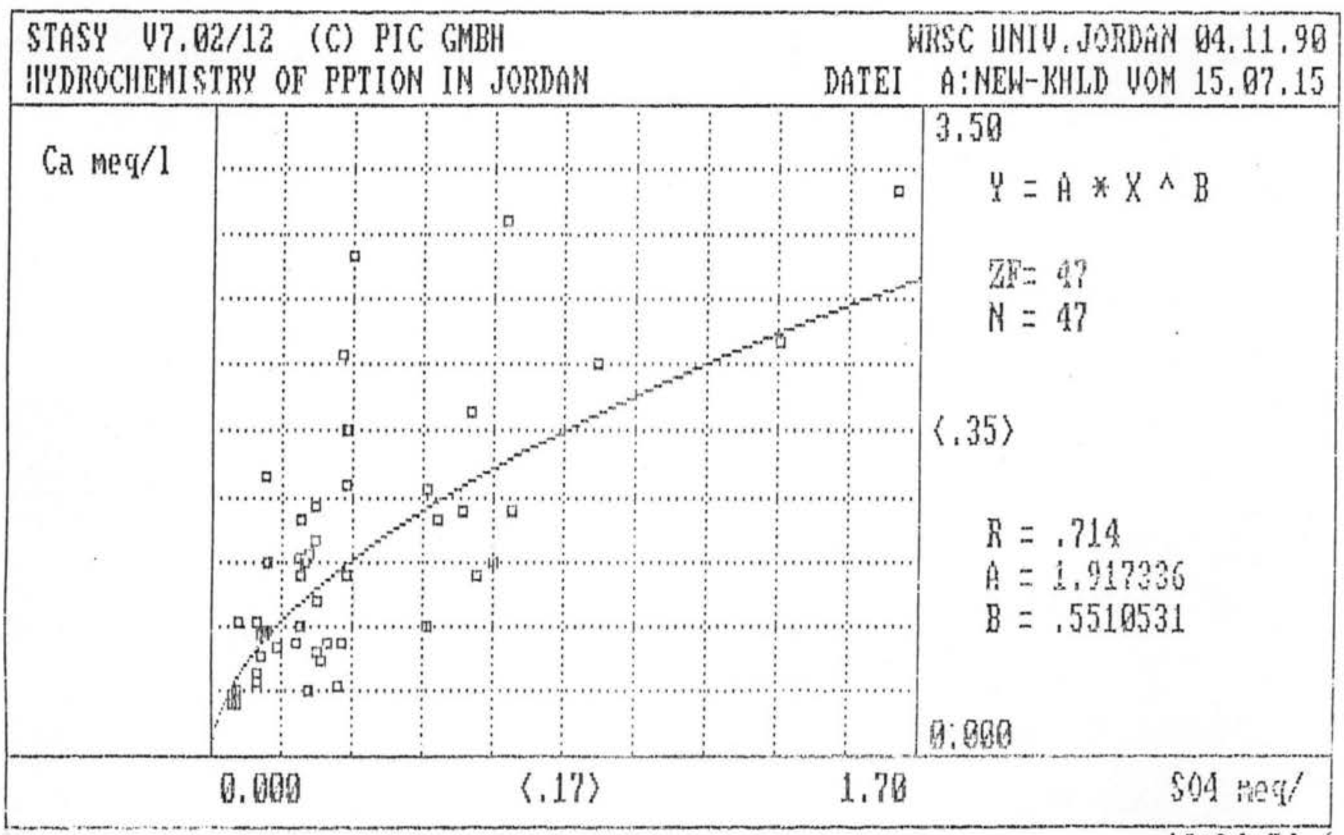
Figure(124): Relationship between EC and SO_4 for Khalidiya Station



Figure(125): Relationship between EC and Mg for Khalidiya Station



Figure(126): Relationship between Ca and HCO_3 for Khalidiya Station



Figure(127): Relationship between Ca and SO_4 for Khalidiya Station

GEO-500 V1.01/P2 (C) PIC GMBH WRSC / UNIVERSITY OF JORDAN / AMMAN
HYDROCHEMISTRY OF PPTION IN JORDAN RUSIEFEH STATION
CORRELATION MATRIX

	DATE	QUANT mm	pH VALUE	EC µS/cm	Na meq/l	K meq/l	Mg meq/l
DATE	1.0000						
QUANT mm	-0.0232	1.0000					
pH VALUE	0.1363	0.3790	1.0000				
EC µS/cm	0.1911	-0.3400	-0.1552	1.0000			
Na meq/l	-0.1208	-0.3330	-0.2992	0.6788	1.0000		
K meq/l	-0.1160	-0.2620	-0.1840	0.4597	0.4695	1.0000	
Mg meq/l	0.1623	-0.1075	0.0040	0.4711	0.1502	0.2756	1.0000
Ca meq/l	0.2840	-0.2531	-0.0542	0.8617	0.3551	0.2250	0.1424
Cl meq/l	0.3019	-0.2893	-0.0618	0.7304	0.5888	0.3661	0.3373
NO3 meq/	0.2014	-0.2122	0.0641	0.6888	0.4051	0.1564	0.7594
SO4 meq/	0.3670	-0.1999	-0.1760	0.8200	0.4540	0.5075	0.5294
HCO3 meq	-0.1624	-0.3303	-0.0665	0.6539	0.2854	0.0497	0.2545
I mg/l	-0.3620	-0.2378	-0.3378	0.1114	-0.0171	0.1737	-0.0190
Br mg/l	0.0172	-0.1609	-0.1657	0.2467	-0.0661	0.2258	-0.0040
F mg/l	0.3031	-0.3858	-0.1765	0.3014	0.3393	0.3761	0.2082
PO4 mg/l	0.0032	0.0867	0.1644	0.3224	0.1435	0.0293	0.1521

	Ca meq/l	Cl meq/l	NO3 meq/	SO4 meq/	HCO3 meq	I mg/l	Br mg/l
Ca meq/l	1.0000						
Cl meq/l	0.5793	1.0000					
NO3 meq/	0.4429	0.4416	1.0000				
SO4 meq/	0.6884	0.4452	0.6495	1.0000			
HCO3 meq	0.6928	0.5264	0.3479	0.2291	1.0000		
I mg/l	0.1699	-0.0387	0.0437	0.1528	0.1683	1.0000	
Br mg/l	0.3863	0.3700	-0.0190	0.1182	0.3963	0.2893	1.0000
F mg/l	0.1386	0.5978	0.0826	0.1877	0.0879	-0.0347	0.1568
PO4 mg/l	0.3277	0.0491	0.4722	0.3635	0.2218	-0.1663	0.1728

	F mg/l	PO4 mg/l
F mg/l	1.0000	
PO4 mg/l	-0.4761	1.0000

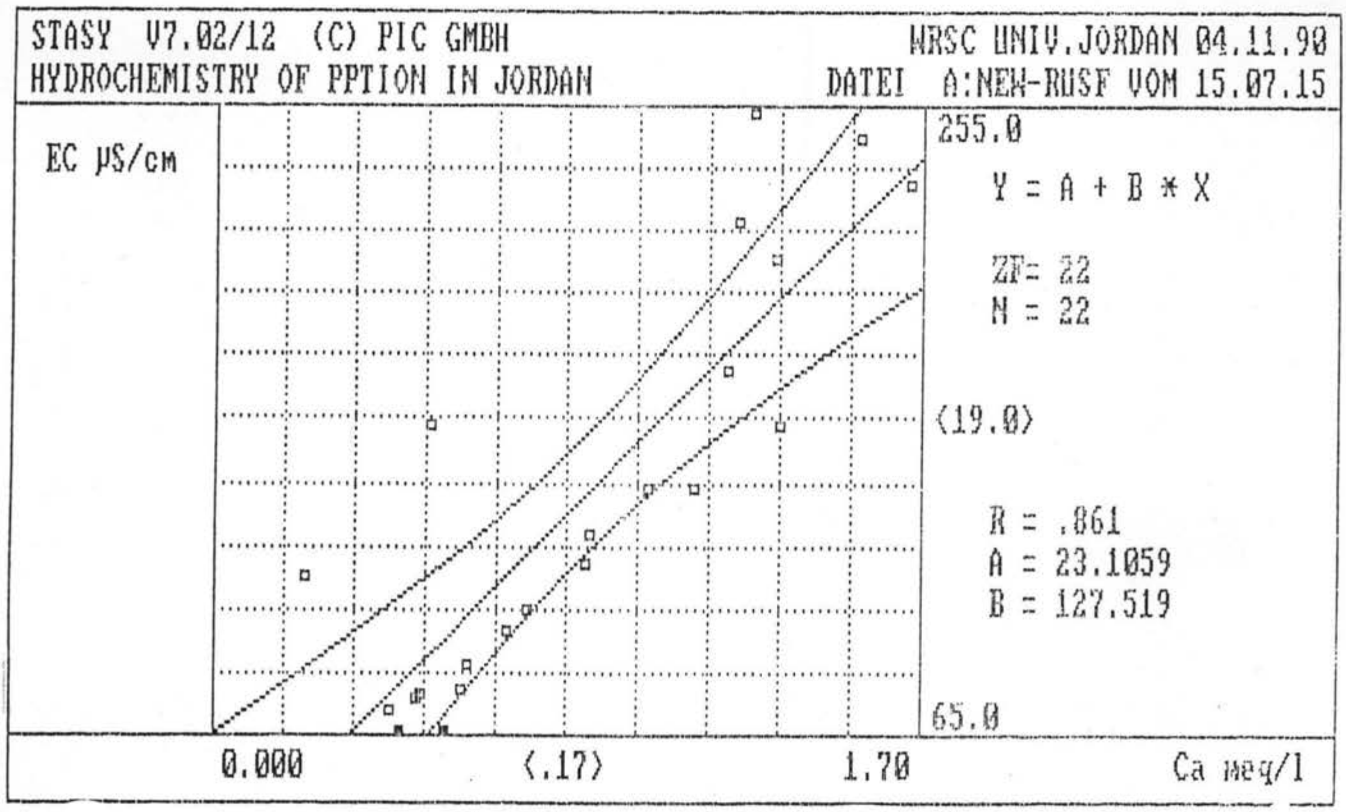
Table(18): Product Moment Correlation for Rusiefeh Station phosphates manufacturing in the area where dust containing phosphate is still produced all over the year. During winter, these dusts and those coming with the khamasien winds had great effect on the rain water quality of the area.

Table (18) shows that the EC correlates significantly with Ca, SO_4, NO_3, Na and HCO_3 and correlates with medium significance with Mg, K, PO_4, and F. some of these correlations are represented in figures (128, 129 and 130).

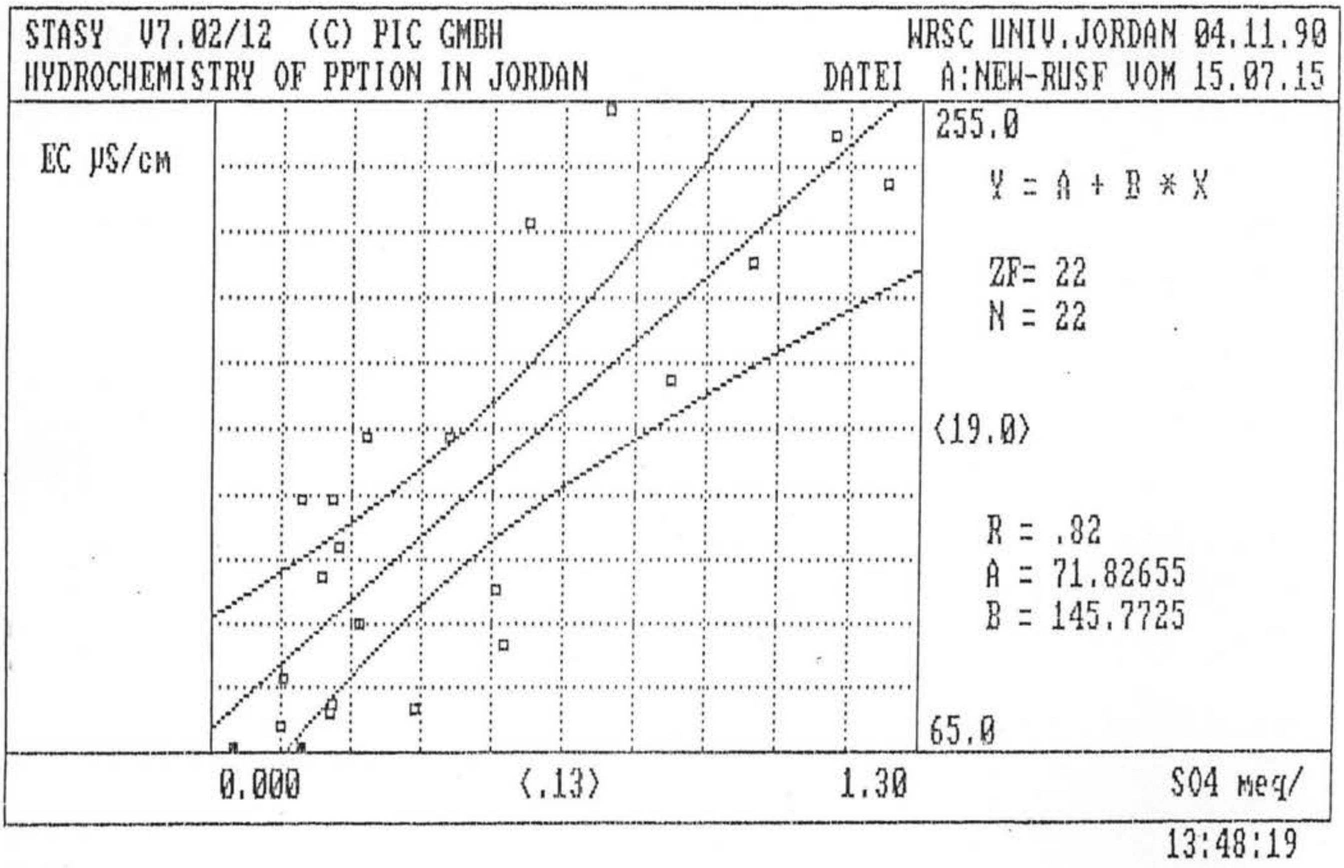
The chemical composition of rain water in Ruseifeh is affected by two main factors; the first one is the original composition of the water vapour whether of a mediterranean , polar or Red Sea origin. The chemical constituents in rain water decrease from the point of origin and continuously as successive raining takes place. The second factor is related to the mineralogical composition of the local dust originating in Ruseifeh area as well as the dust carried with the khamasien winds. However, the ppt. water in this station is characterized by the presence of orthophosphate and fluoride which distinguishes it from all other rainfalls in Jordan.

Table (18) shows that the electrical conductivity of rain water samples collected from Azraq is significantly and directly correlated with Ca, HCO_3, Cl, K, Mg, SO_4, F, Na, NO_3, Li and PO_4 with correlation coefficients of 0.874, 0.821, 0.816, 0.795, 0.789, 0.783, 0.758, 0.736, 0.690, 0.489 and 0.418 respectively.

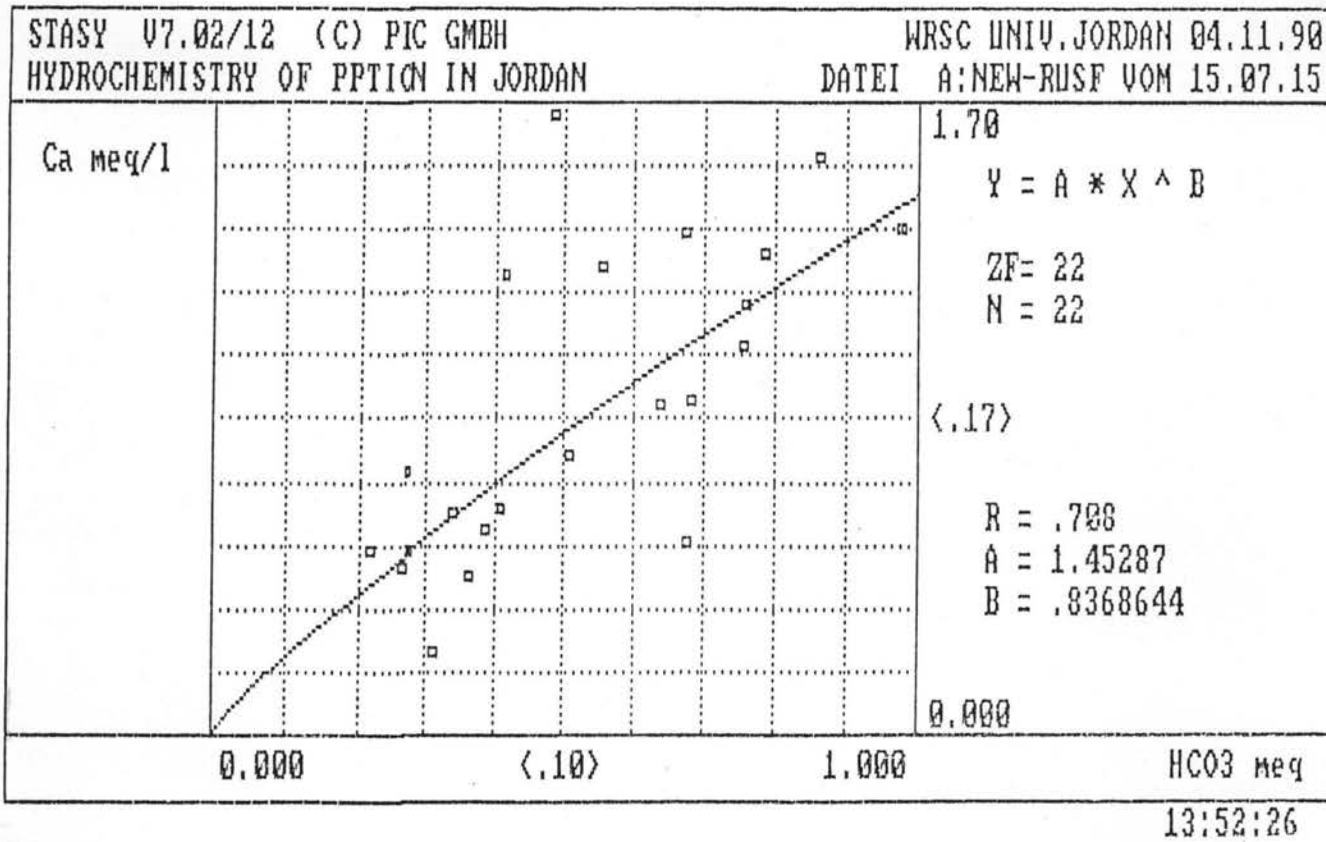
The relationships between EC and Ca, HCO_3, F, PO_4, Cl and Na are represented in figures (131, 132, 133, 134, 135 and 136) respectively. These relations and the correlations between all other parameters as well as the local condition in Azraq indicate



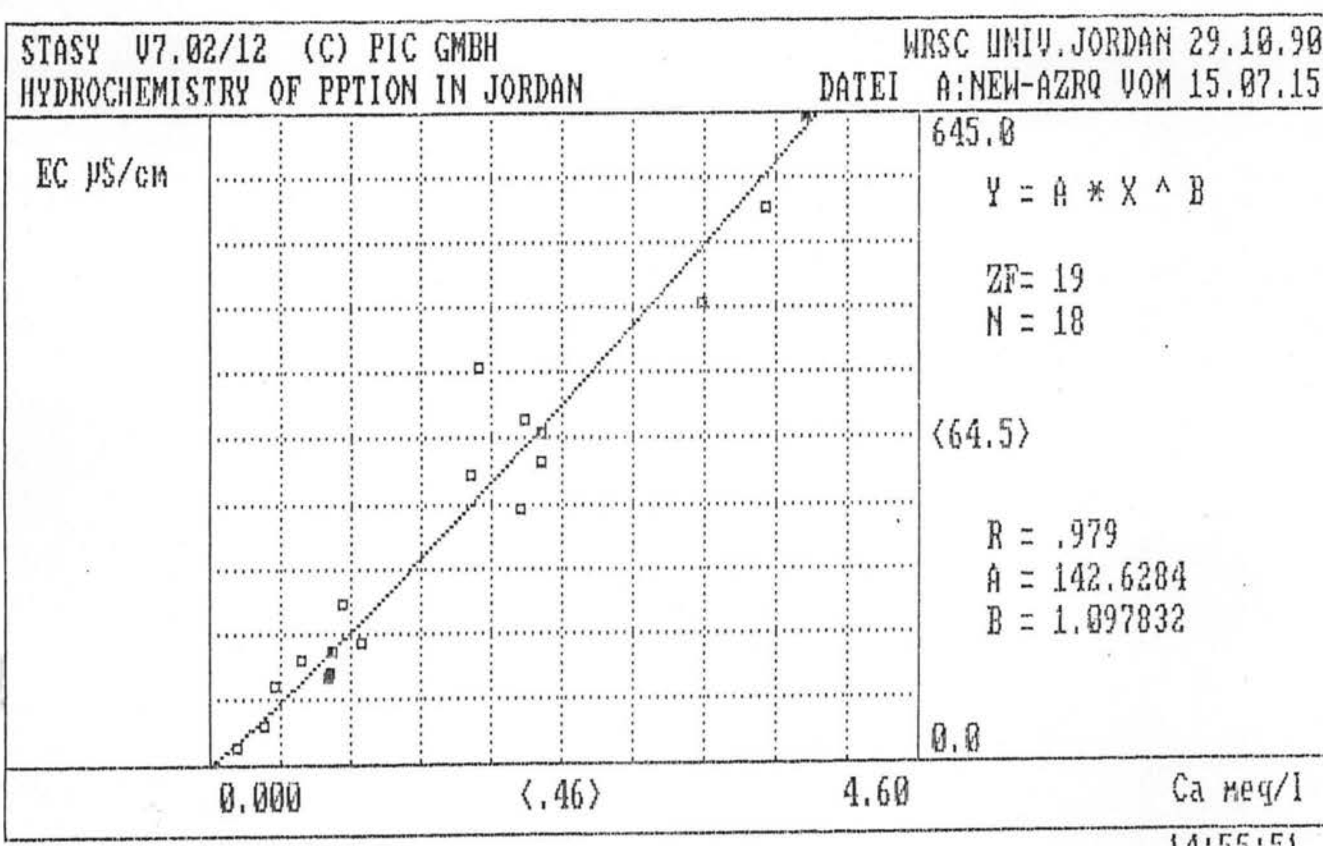
Figure(128): Relationship between EC and Ca for Rusiefeh Station



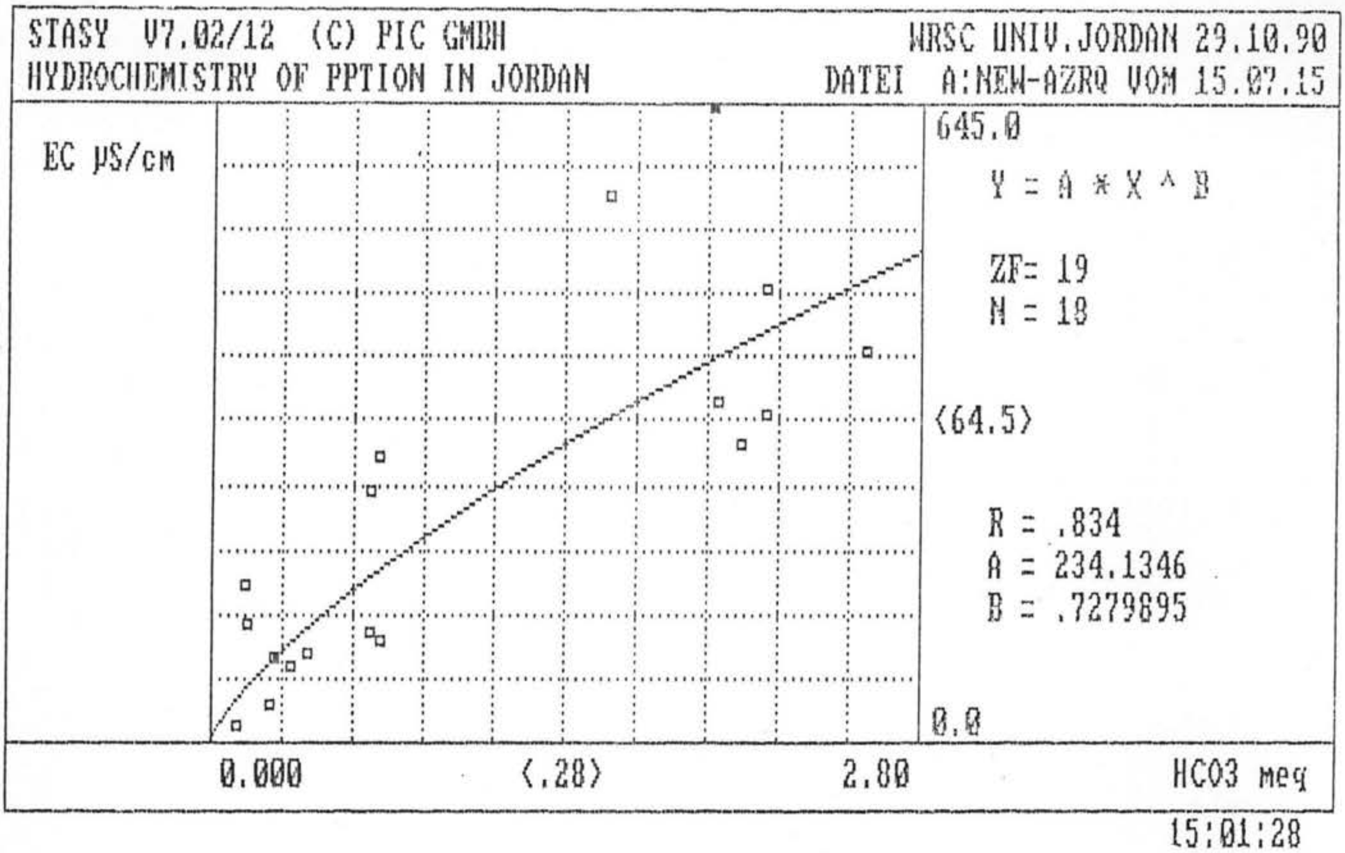
Figure(129): Relationship between EC and SO_4 for Rusiefeh Station



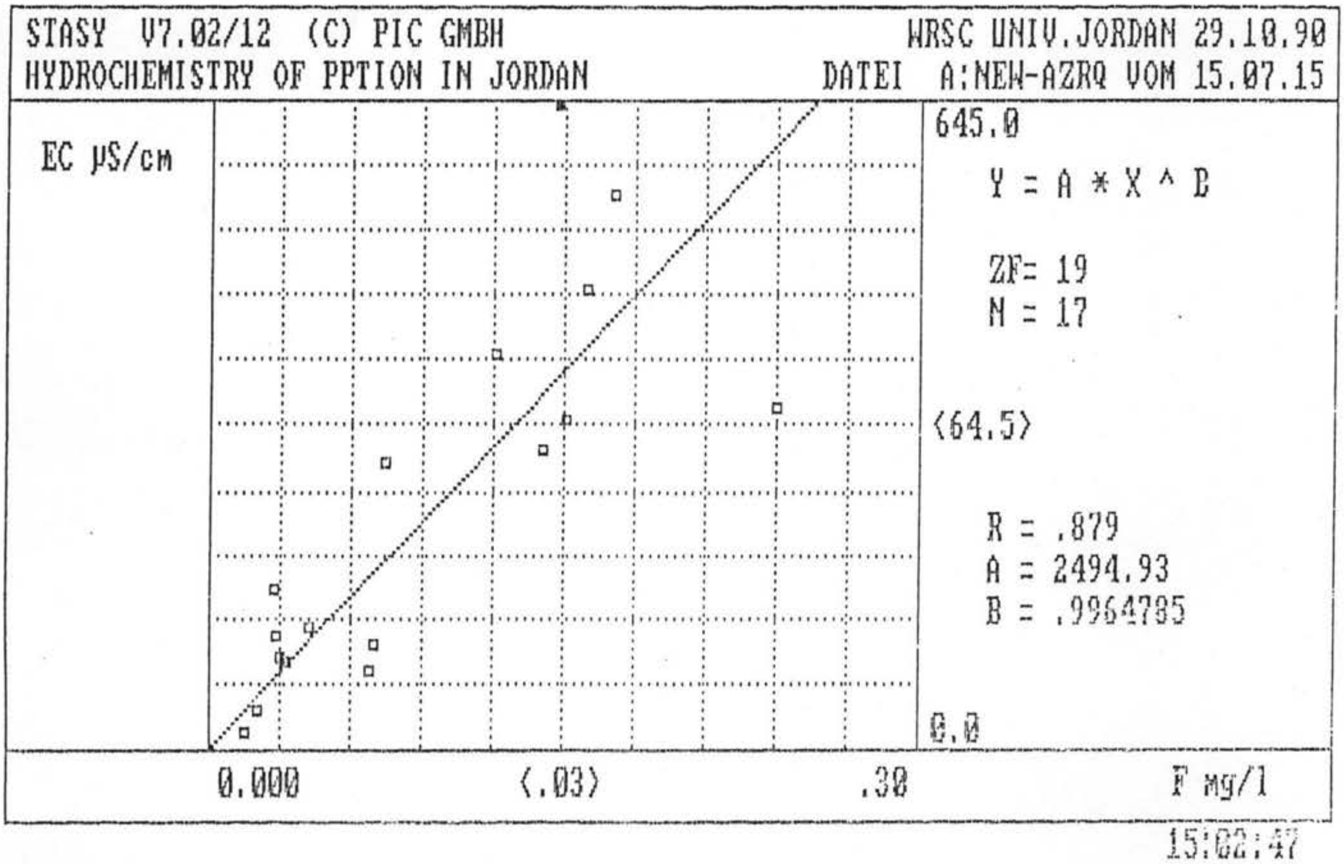
Figure(130): Relationship between Ca and HCO_3 for Rusiefeh Station



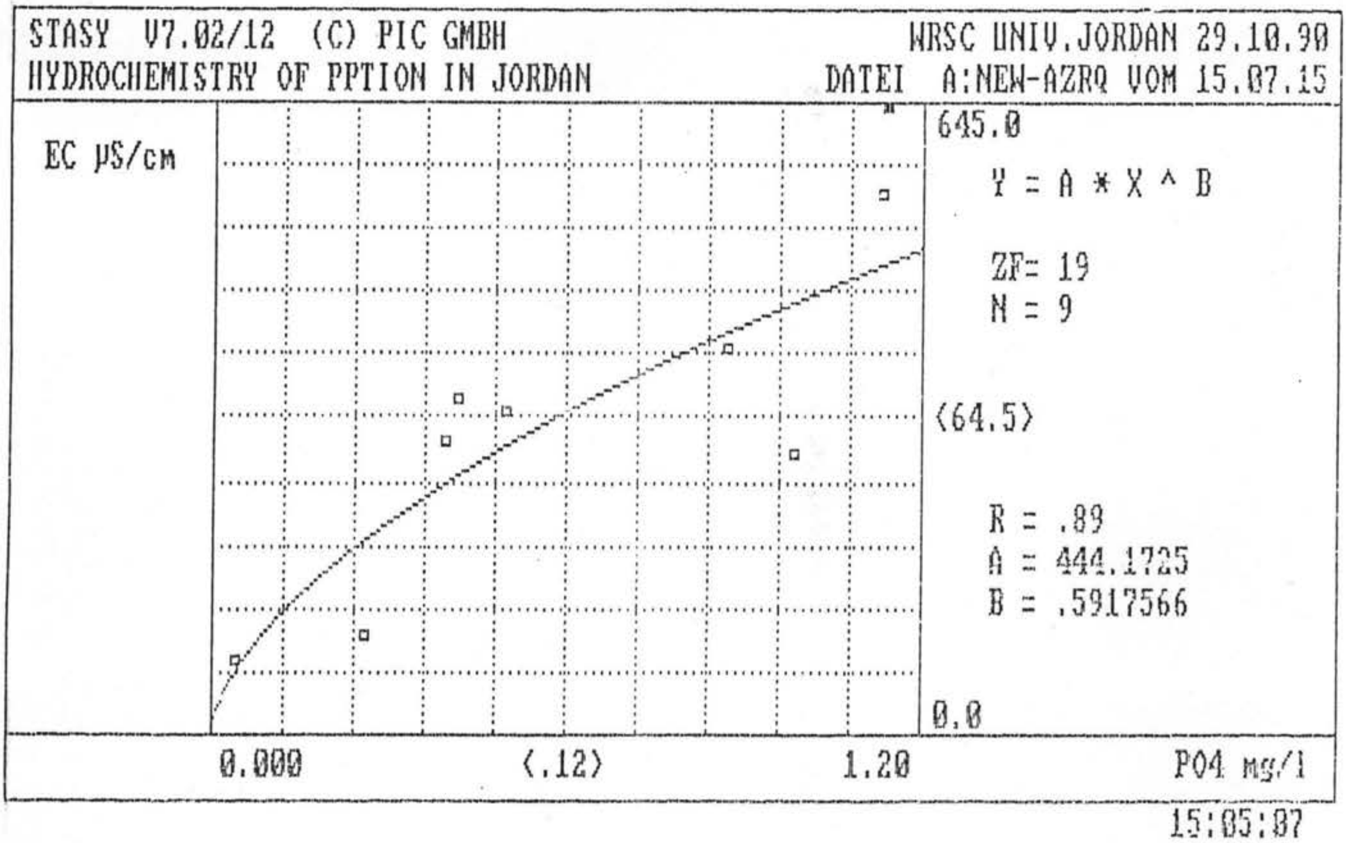
Figure(131): Relationship between EC and Ca for Azraq Station



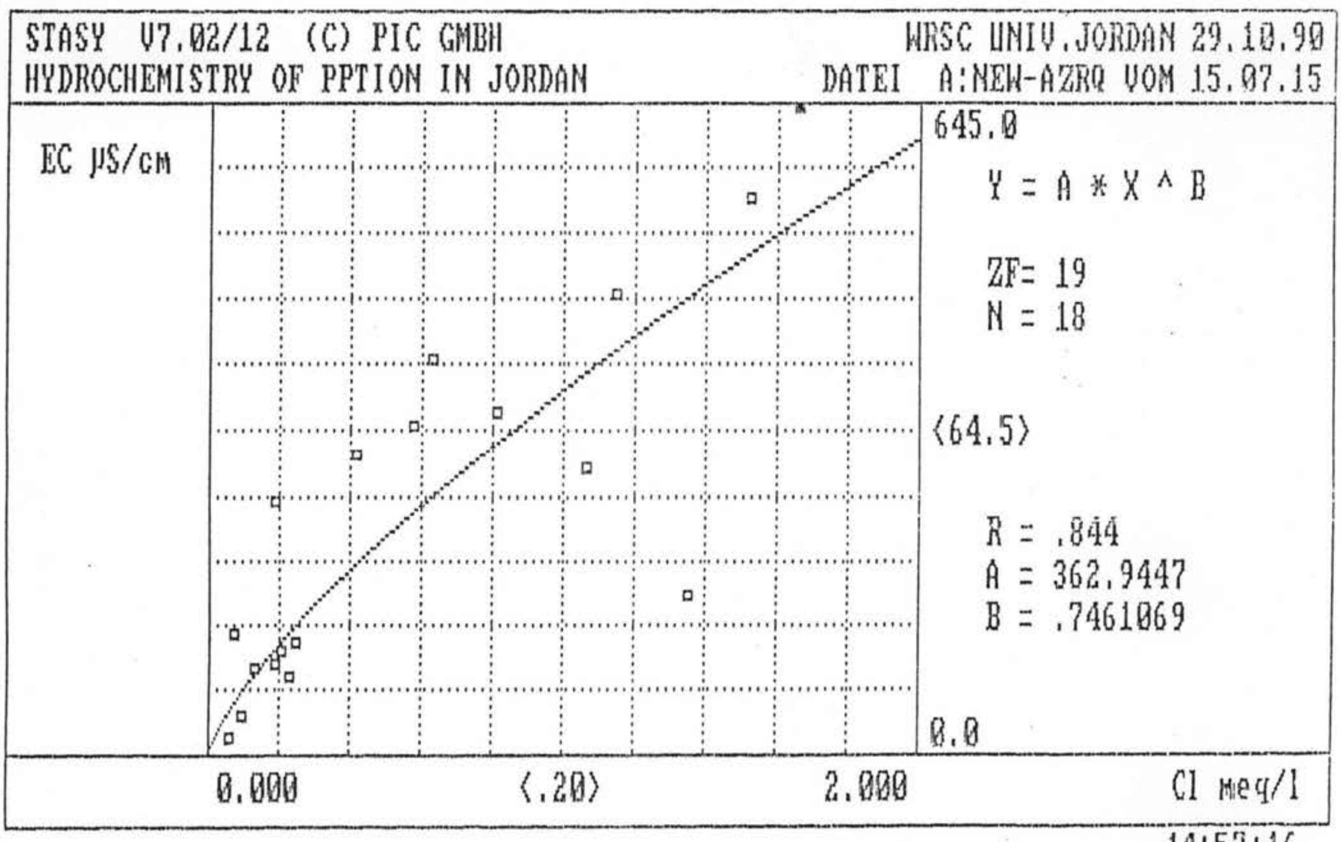
Figure(132): Relationship between EC and HCO_3 for Azraq Station



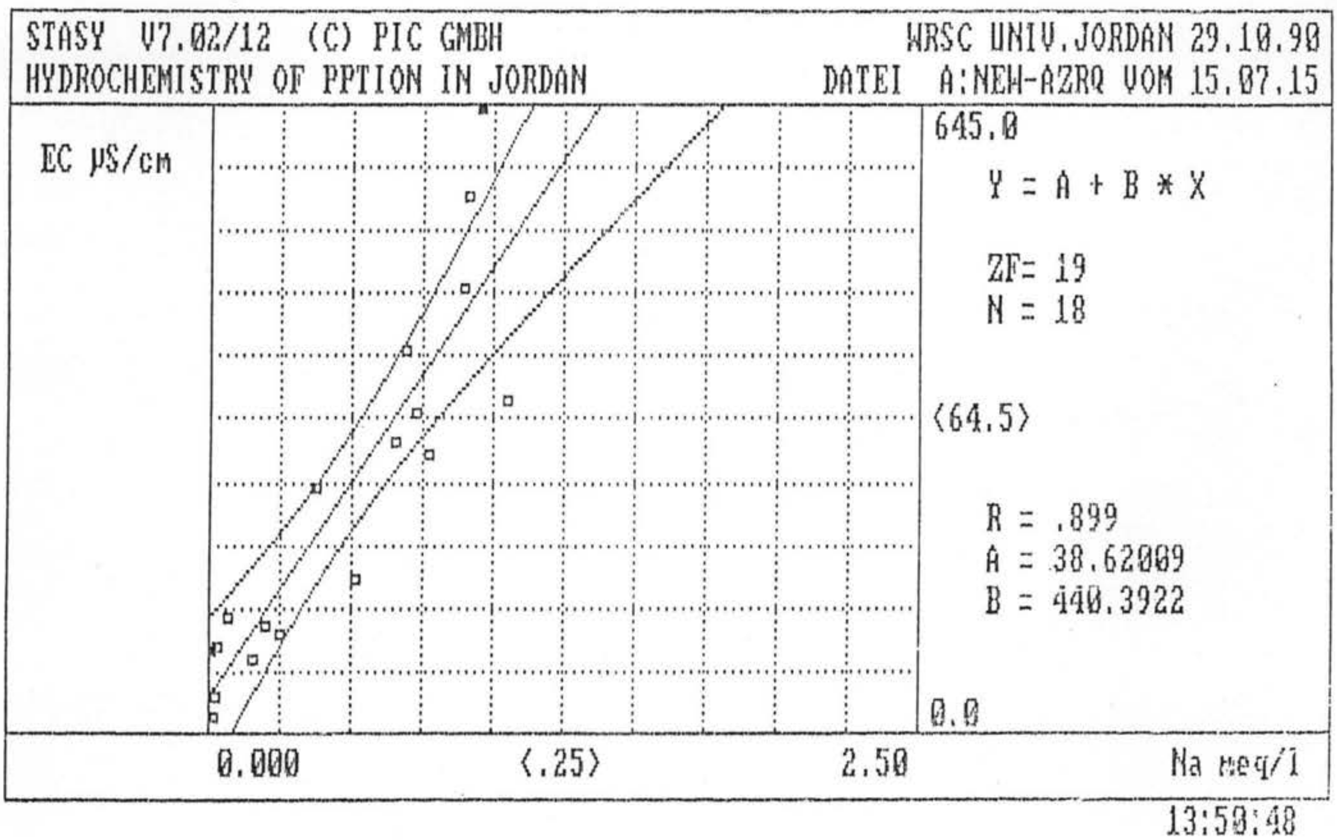
Figure(133): Relationship between EC and F for Azraq Station



Figure(134): Relationship between EC and PO_4 for Azraq Station



Figure(135): Relationship between EC and Cl for Azraq Station



Figure(136): Relationship between EC and Na for Azraq Station

QEO-500 V1.01/P2 (C) PIC GMBH WRSC / UNIVERSITY OF JORDAN /AMMAN
HYDROCHEMISTRY OF PPTION IN JORDAN AZRAQ RAINFALL
FACTOR LOADINGS - VARIMAX ROTATION

	FACT-1	FACT-2	FACT-3	FACT-4	FACT-5	FACT-6	KOMMUN.
PO4 mg/l	0.8934						0.897
Ca meq/l	0.8170	0.3398	0.3497				0.925
NO3 meq/	0.8085	0.3681					0.838
SO4 meq/	0.7207	0.3455		0.3610			0.832
DATE	0.6677	0.3753	0.3108	-0.3640			0.917
Na meq/l		0.9770					0.977
Cl meq/l	0.3643	0.8883					0.982
K meq/l		0.7437	0.3401	0.3609			0.867
ECµS/cm	0.6184	0.7186					0.992
Mg meq/l	0.4655	0.5901			-0.4184		0.835
F mg/l	0.3031	0.5821	0.5041			0.3236	0.879
HCO3 meq	0.3818	0.5643	0.4972			0.3545	0.849
QUANT mm			0.8071	0.4092			0.878
I mg/l		-0.3436	-0.6947				0.623
TEMP°C				0.9351			0.887
pH VALUE	0.3507			0.6990		0.3835	0.872
TURBIDY					0.9251		0.918
Li mg/l	0.5840				-0.6092		0.783
Br mg/l						-0.9198	0.885
SS	4.5825	4.5704	2.1946	2.1246	1.6611	1.5020	16.635
% VA	24.1184	24.0546	11.5507	11.1821	8.7425	7.9053	87.554

Table(19): Factor Loadings for Azraq Station that rain water salinizations are a function of many factors as indicated in table (19). Table (19) shows the factor loadings (6-factors) of varimax rotation of factor analyses. The first three factors are of importance. The explanation of these factors can be summarized as follows:

Factor (1) explains the following parameters in the order of their loadings PO_4, Ca, NO_3, SO_4, Cl, EC, Mg, F, HCO_3, pH and Li. This factor represents the local conditions in the basin (irrigation, addition of fertilizers, and dusts originating from the saline soils in the basin where fertilizers are added to irrigated lands), thus the high salinity of rain waters in this area is attributed to local conditions within the basin.

Factor (2) explains the following parameters in the order of their loading Na, Cl, K, EC, Mg, F, HCO_3, NO_3, SO_4 and Ca. This factor represents the parameters characterizing the cloud vapour waters from their sources, whether polar or Mediterranean or red sea.

Factor (3) explains the following parameters in the order of their loadings; amount of rainfall, F, HCO_3, Ca, and K. This factor indicates that the higher the amount of rainfall the higher the concentration of F, HCO_3, Ca and K. This condition is restricted to Red Sea and eastern depressions affecting the area.

Rabba area

The interrelationships between the different measured parameters of ppt. water samples collected from Rabba station are shown in the correlation matrix table (20). From table (20) it can be seen that the EC - value correlates with high significance

GEO-500 V1.01/P2 (C) PIC GMBH WRSC / UNIVERSITY OF JORDAN / AMMAN
HYDROCHEMISTRY OF PPTION IN JORDAN RABBA STATION
CORRELATIO SMATRIX

	DATE	QUANT mm	TEMP °C	pH VALUE	EC µS/cm	Na meq/l	K meq/l
DATE	1.0000						
QUANT mm	0.0888	1.0000					
TEMP °C	0.2991	-0.0201	1.0000				
pH VALUE	0.0814	0.0809	0.0072	1.0000			
EC µS/cm	0.0120	-0.3713	0.1506	0.0423	1.0000		
Na meq/l	-0.0242	-0.1983	0.2592	-0.0326	0.6843	1.0000	
K meq/l	-0.5032	-0.2399	0.1133	0.1069	0.5168	0.2818	1.0000
Mg meq/l	-0.2041	-0.2378	-0.0590	-0.0480	0.6763	0.3989	0.2525
Ca meq/l	0.1711	-0.3505	0.0832	0.1011	0.8394	0.2451	0.4506
Cl meq/l	-0.0336	-0.2772	0.2673	-0.0660	0.8417	0.7085	0.5459
NO3 meq/	0.2105	-0.3981	0.2777	0.0384	0.7117	0.2673	0.5320
SO4 meq/	0.0303	-0.4105	0.1203	-0.0912	0.7800	0.6096	0.3318
HCO3 meq	0.0292	-0.2751	-0.0170	0.1678	0.7815	0.4318	0.3151
I mg/l	0.1345	0.2433	-0.1064	0.1654	-0.0499	-0.1051	-0.0304
Br mg/l	-0.3719	-0.0744	0.1881	-0.2350	0.0254	0.0876	0.2037
F mg/l	0.4292	-0.1401	0.0375	0.0816	0.0423	-0.1154	-0.3675
PO4 mg/l	0.1323	-0.1984	0.4054	-0.0145	-0.0567	0.0556	0.1040
Li mg/l	-0.2400	-0.1186	-0.2979	0.1596	0.2190	-0.0077	0.0601
TURBIDY	0.1884	-0.0917	0.3100	0.0638	0.0851	-0.0251	0.1055

	Mg meq/l	Ca meq/l	Cl meq/l	NO3 meq/	SO4 meq/	HCO3 meq	I mg/l
Mg meq/l	1.0000						
Ca meq/l	0.3946	1.0000					
Cl meq/l	0.6596	0.5673	1.0000				
NO3 meq/	0.2434	0.8304	0.5710	1.0000			
SO4 meq/	0.6939	0.5407	0.7494	0.5454	1.0000		
HCO3 meq	0.3710	0.8009	0.3722	0.5314	0.3363	1.0000	
I mg/l	-0.0081	-0.0037	-0.0445	-0.0751	-0.1010	-0.0082	1.0000
Br mg/l	0.1780	-0.1120	0.1993	-0.1057	0.0153	-0.1027	-0.0059
F mg/l	-0.0098	0.1886	-0.0735	0.0486	0.0505	0.1149	-0.0488
PO4 mg/l	-0.1953	-0.0600	0.0258	0.1628	0.0439	-0.1607	-0.0818
Li mg/l	0.3956	0.1934	0.0954	-0.0067	0.0575	0.3113	-0.0317
TURBIDY	-0.0678	0.1744	0.0559	0.3290	0.0468	0.0667	-0.1763

	Br mg/l	F mg/l	PO4 mg/l	Li mg/l	TURBIDY
Br mg/l	1.0000				
F mg/l	-0.2720	1.0000			
PO4 mg/l	0.0103	0.1487	1.0000		
Li mg/l	0.1078	-0.0198	-0.0572	1.0000	
TURBIDY	-0.0032	-0.0465	0.2219	-0.0763	1.0000

Table(20): Product Moment Correlation for Rabba Station with Cl, Ca, HCO_3, and SO_4 with correlation coefficients of 0.842, 0.839, 0.782 and 0.780 respectively. Other ions correlate significantly with EC, these ions are NO_3, Na, Mg, and K, their correlation coefficients are 0.712, 0.684, 0.676 and 0.517 respectively. Some of these correlations are represented in figures (137, 138, 139, 140, 141 and 142). The rain water chemistry falling on the area is influenced by many factors. These factors are :

1- Mediterranean and polar depressions affecting Jordan, the ion concentrations which reversely correlate with the amount of ppt. these ions are Na, Cl, Mg, and SO_4.

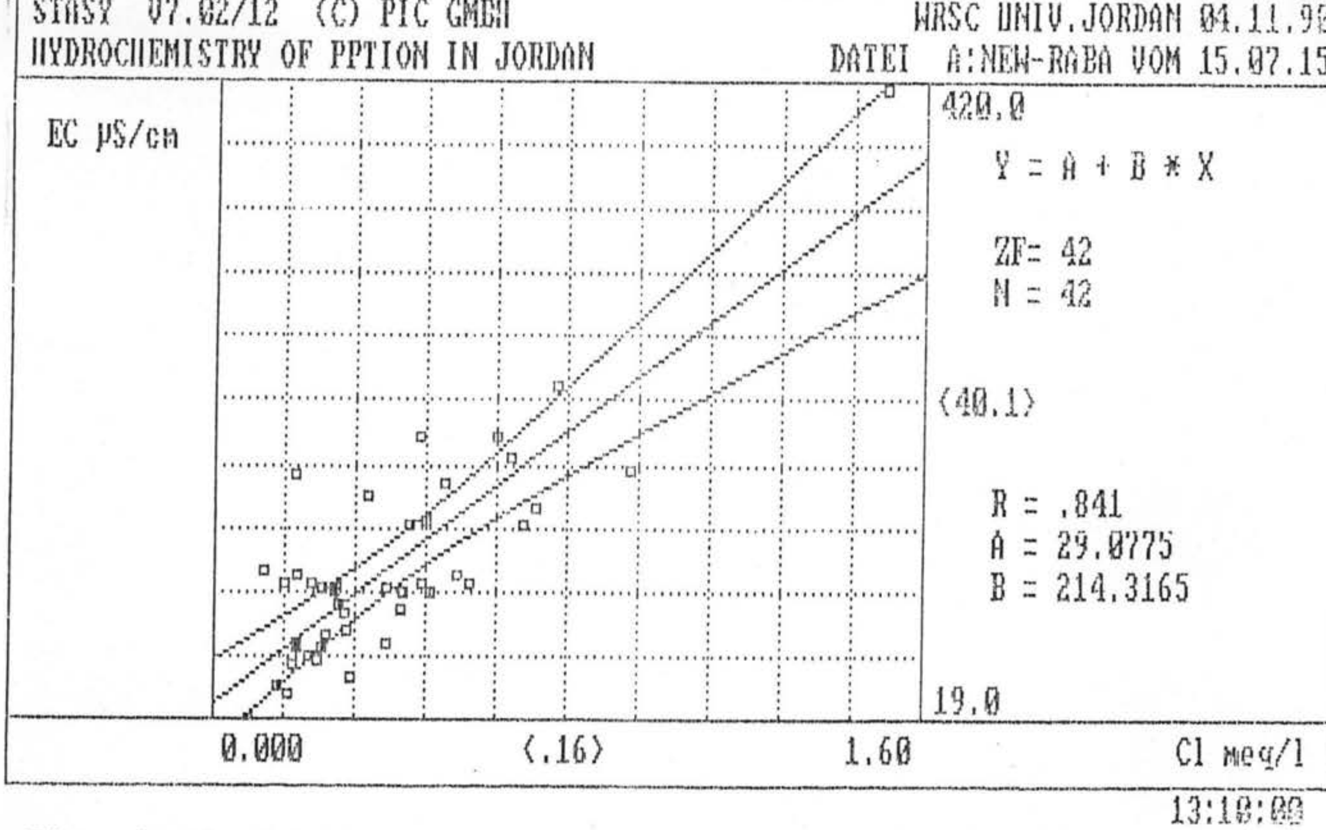
2- Eastern and Red Sea depressions where mostly associate with dust and higher salinities than the Mediterranean and Polar depressions.

3-Dead Sea. Most of rainfall originating from the Mediterranean (moderate to low depressions and passing over the Dead Sea) is characterized by small amounts of rainfall and higher contents of Mg, K, Cl, and Ca from the major ions in addition to higher content of bromide.

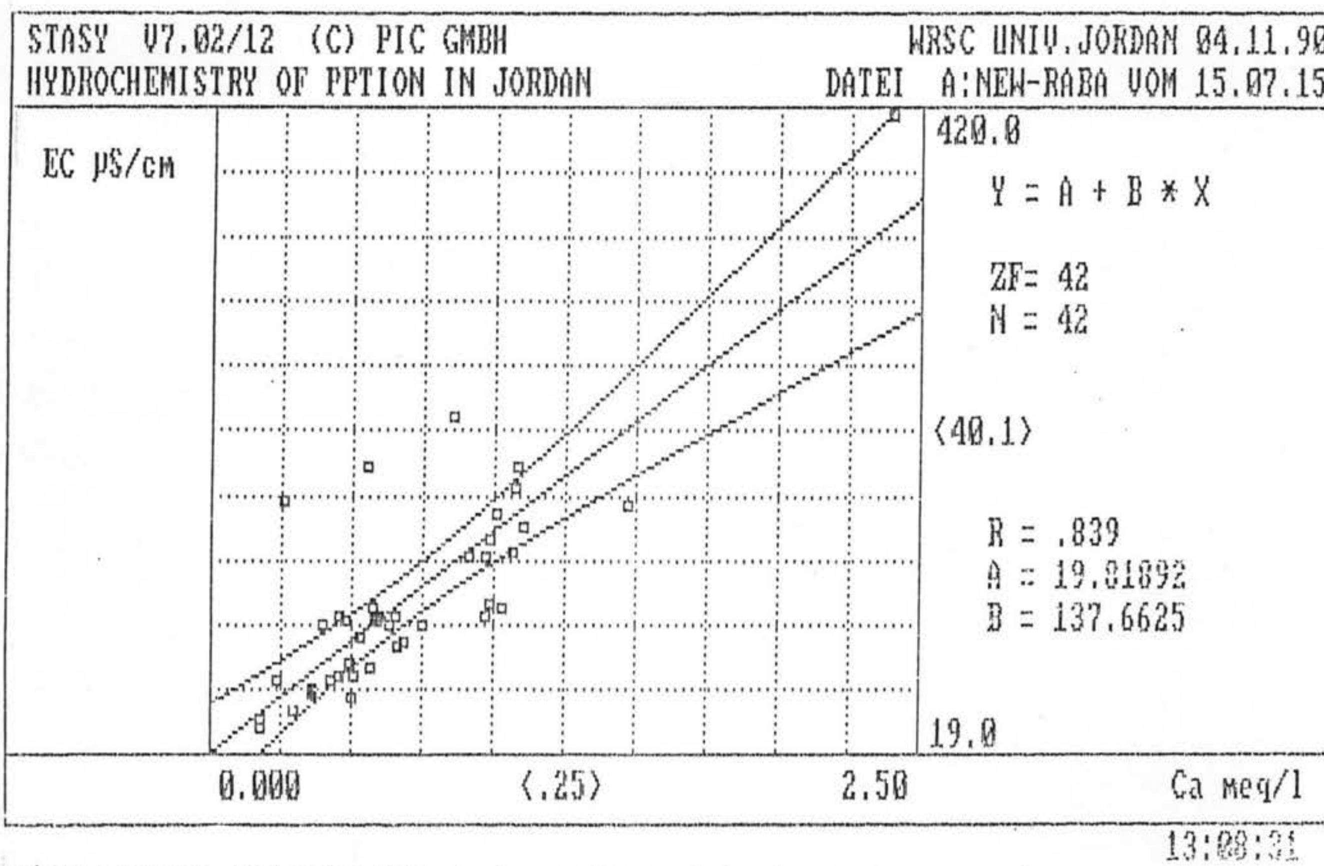
4- The local and surrounding conditions. This factor is related to agricultural activities surrounding the station and the intense thunderstorms causing higher concentrations of NO_3 and PO_4 beside other ions.

The Ghore area.

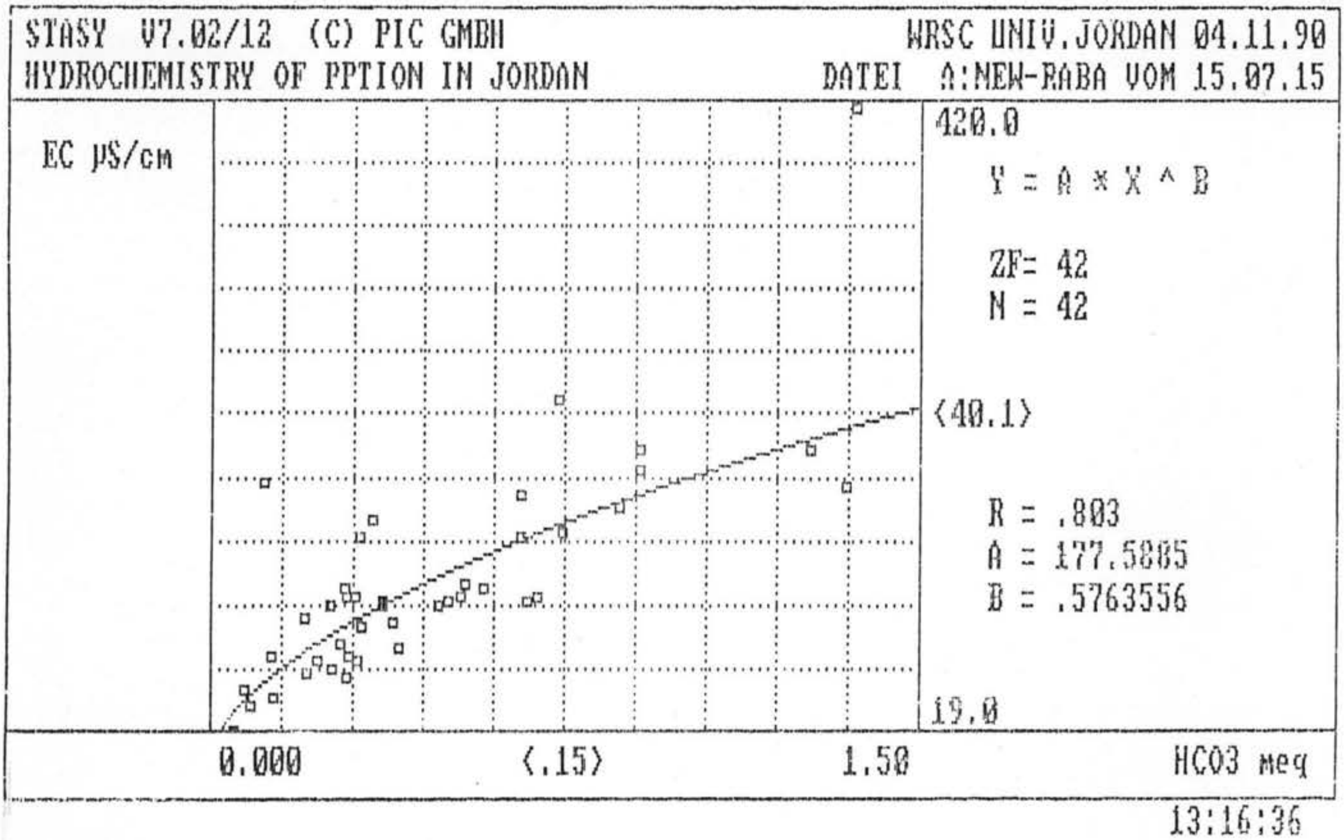
In the installed station at the University of Jordan farm in the Ghore area to collect the rain water precipitated in the central part of the Jordan Valley area, the chemistry of rain water was



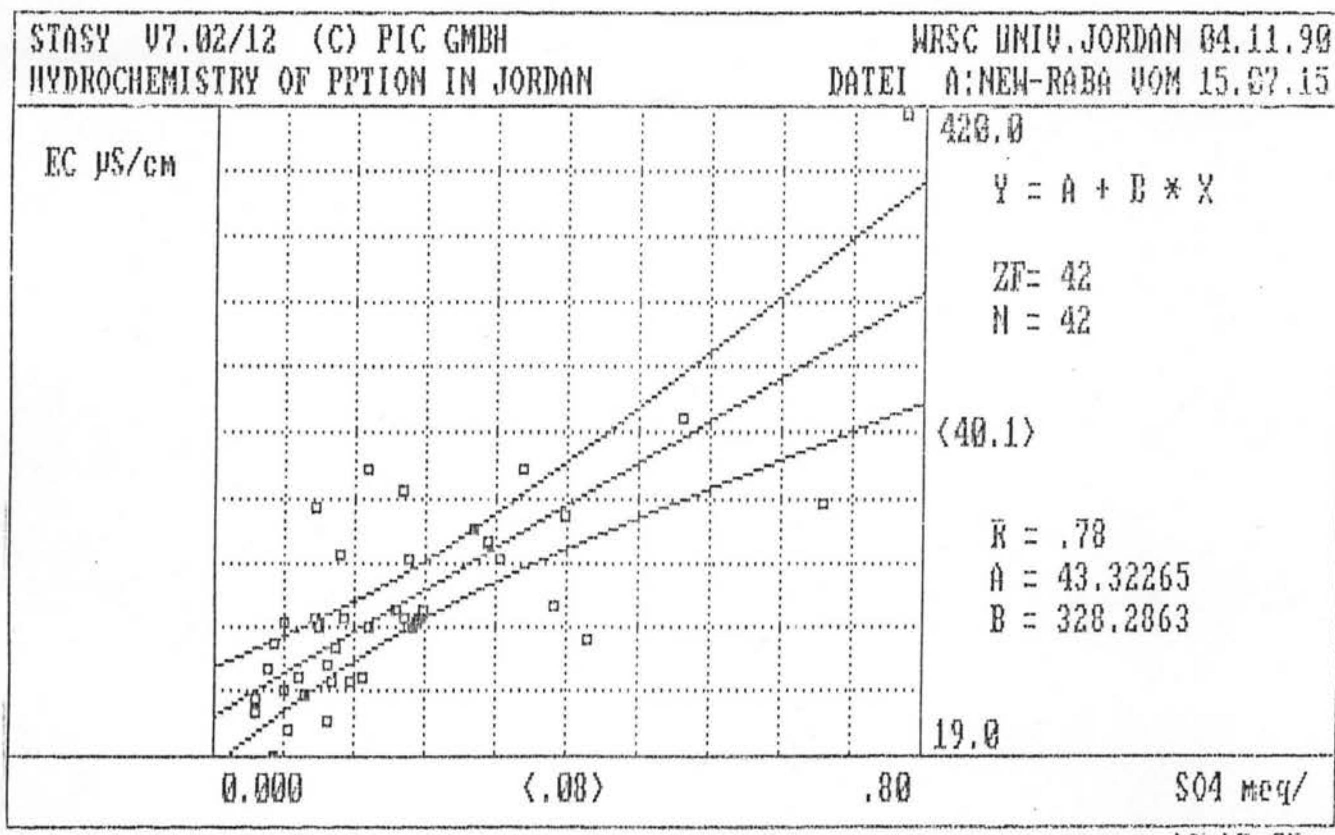
Figure(137): Relationship between EC and Cl for Rabba Station



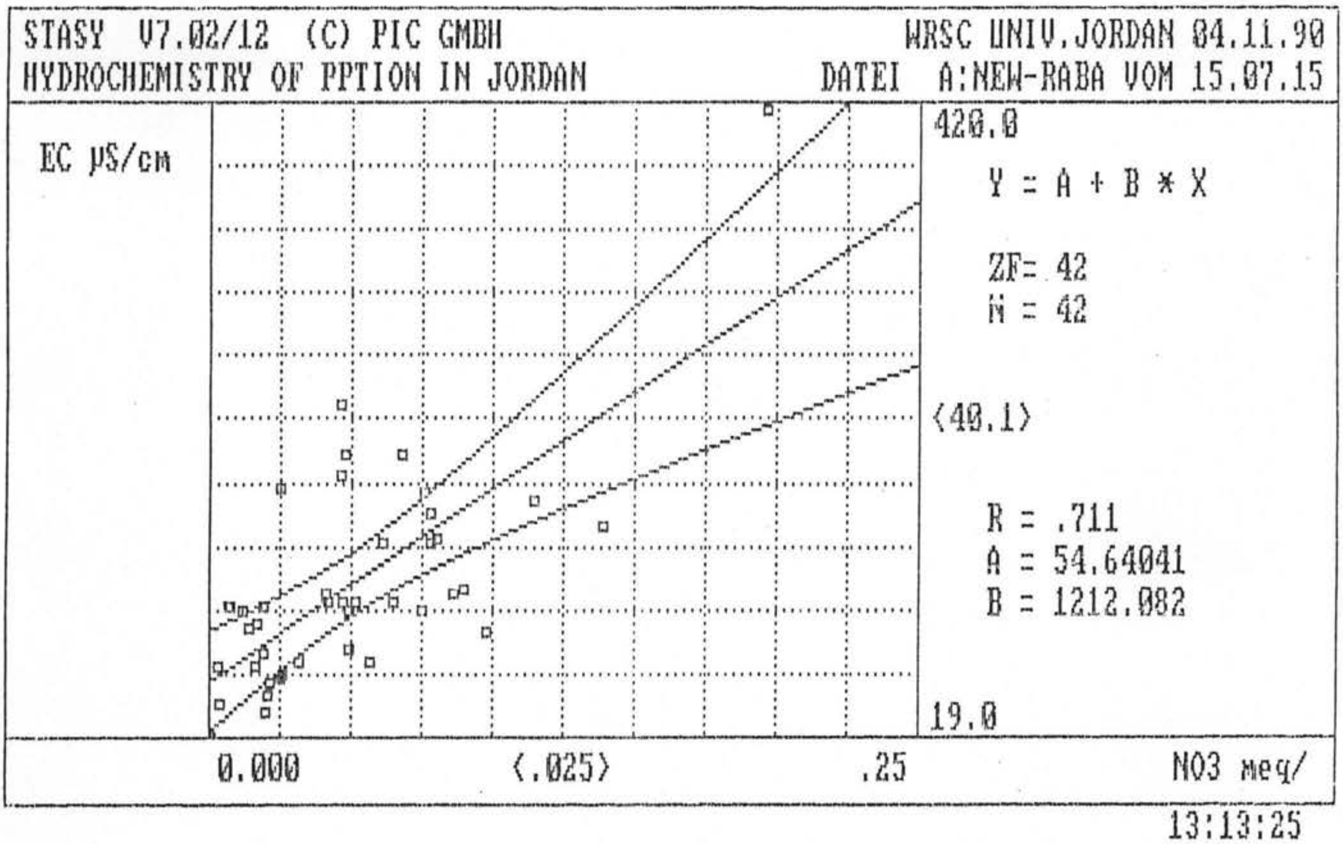
Figure(138): Relationship between EC and Ca for Rabba Station



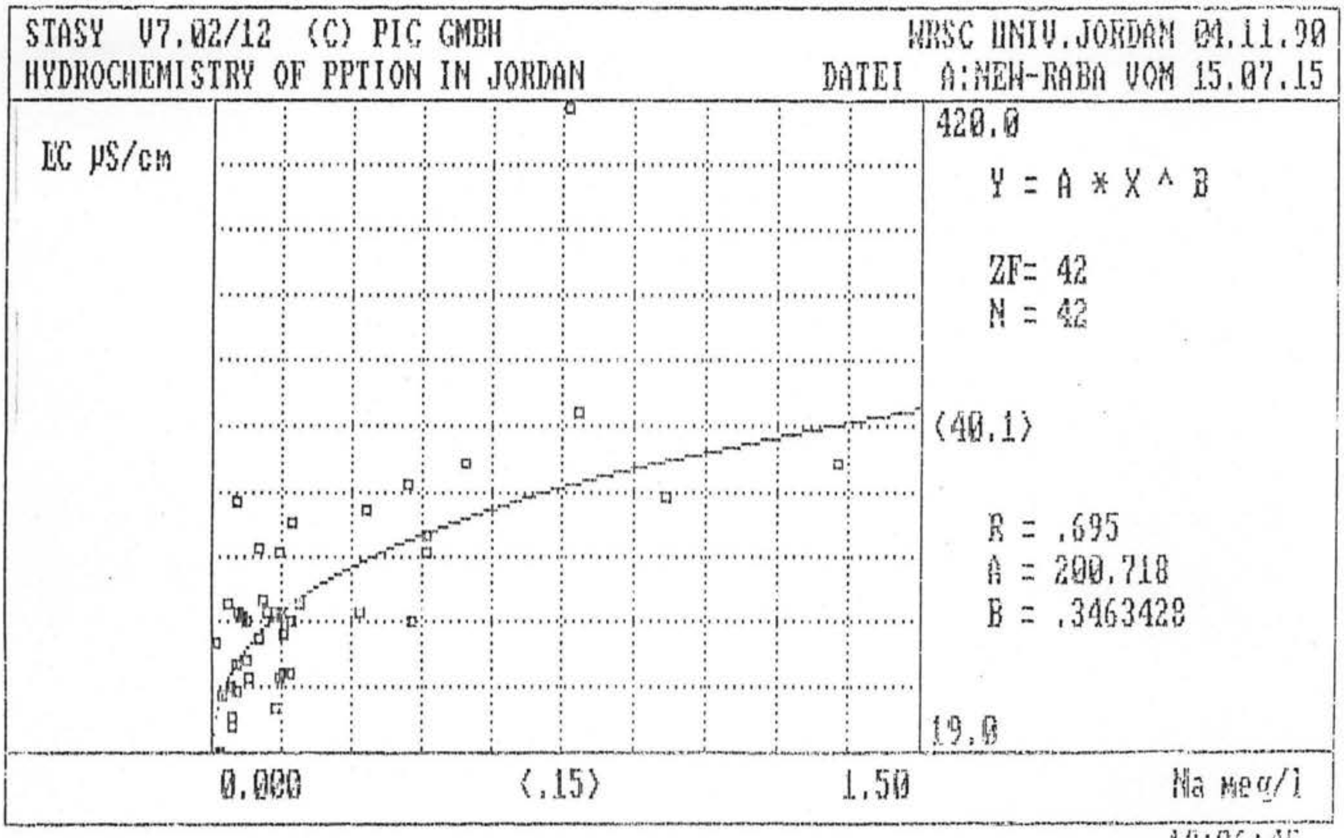
Figure(139): Relationship between EC and HCO_3 for Rabba Station



Figure(140): Relationship between EC and SO_4 for Rabba Station



Figure(141): Relationship between EC and NO_3 for Rabba Station



Figure(142): Relationship between EC and Na for Rabba Station highly influenced by the local conditions in the surrounding areas. These conditions are due to the influence of the Dead Sea, the saline soils and the intensive agriculture.

The product moment correlations of the measured parameters are listed in table (21). Table (21) shows that most of the analysed parameters are significantly correlated with each other, major cations and anions are correlated with high significant with each other as well as with the EC. The correlation coefficients of EC with Ca, K, Cl, Mg, HCO_3, SO_4, Na, F, Li, NO_3, are 0.992, 0.993, 0.988, 0.972, 0.971, 0.965, 0.956, 0.896, 0.853, and 0.846 respectively. Some of these correlations are represented in figures (143, 144, 145, 146, 147, 148 and 149). The high correlation coefficient between EC and K, Cl, Mg, Ca, and Na can be explained by the influence of the clouds passing over the area. The other ions such as NO_3, Li, SO_4, F, HCO_3, Ca, K, Cl, Mg and Na, are mainly derived from the dusty material originating from the saline soils in the area. The influence of agricultural activities in the rain water chemistry is indicated by the high content of NO_3 and PO_4.

Muwaqqar Area.

The product linear moment correlations of the measured parameters are listed in table (22). Table (22) shows that correlation coefficients between the major ions are varied between high and low coefficients. But concerning the correlation coefficients between EC and the major ions, these vary between very high to moderate coefficients. These correlations between EC and Ca, HCO_3, SO_4, Na, Cl, Mg, K, and NO_3

GEO-500 V1.01/P2 (C) PIC GMBH — WRSC / UNIVERSITY OF JORDAN / AMMAN
HYDROCHEMISTRY OF PPTION IN JORDAN — UNIVERSITY FARM STATION
CORRELATION MATRIX

	DATE	QUANT mm	pH VALUE	EC µS/cm	Na meq/l	K meq/l	Mg meq/l
DATE	1.0000						
QUANT mm	-0.0311	1.0000					
pH VALUE	0.6157	-0.0932	1.0000				
EC µS/cm	0.3466	-0.0024	0.4346	1.0000			
Na meq/l	0.3383	0.0958	0.4670	0.9558	1.0000		
K meq/l	0.3930	-0.0395	0.4523	0.9915	0.9485	1.0000	
Mg meq/l	0.3124	-0.0076	0.3981	0.9719	0.8789	0.9621	1.0000
Ca meq/l	0.3565	-0.0384	0.4264	0.9920	0.9496	0.9832	0.9427
Cl meq/l	0.3457	-0.0845	0.4727	0.9880	0.9371	0.9842	0.9555
NO3 meq/	0.2805	-0.1016	0.3706	0.8464	0.8127	0.8422	0.8349
SO4 meq/	0.3283	-0.0161	0.3575	0.9645	0.8830	0.9543	0.9701
HCO3meq/	0.3370	0.0950	0.4108	0.9710	0.9566	0.9589	0.9302
I mg/l	0.4599	0.1648	0.3202	0.4124	0.4606	0.4372	0.4038
Br mg/l	0.0585	-0.0272	-0.0381	0.4173	0.4979	0.4164	0.3013
F mg/l	0.3645	-0.1489	0.5016	0.8958	0.8580	0.8949	0.8337
PO4 mg/l	-0.1108	0.3627	-0.0231	0.1422	0.1030	0.1190	0.2339
Li mg/l	0.0103	0.1625	0.2150	0.8530	0.7579	0.8168	0.8994
TURBIDY	-0.2102	0.4780	-0.2636	0.2964	0.2185	0.2316	0.3951

	Ca meq/l	Cl meq/l	NO3 meq/	SO4 meq/	HCO3meq/	I mg/l	Br mg/l
Ca meq/l	1.0000						
Cl meq/l	0.9865	1.0000					
NO3 meq/	0.8282	0.8588	1.0000				
SO4 meq/	0.9483	0.9591	0.8285	1.0000			
HCO3meq/	0.9617	0.9301	0.7784	0.8915	1.0000		
I mg/l	0.3763	0.3521	0.4618	0.3593	0.4737	1.0000	
Br mg/l	0.4522	0.3379	0.2435	0.2614	0.5649	0.3385	1.0000
F mg/l	0.9162	0.9323	0.7264	0.8683	0.8200	0.1580	0.3157
PO4 mg/l	0.0822	0.0760	0.1307	0.1231	0.2123	0.1682	-0.1024
Li mg/l	0.8181	0.8410	0.7317	0.8727	0.8024	0.1769	0.1073
TURBIDY	0.2427	0.2030	0.2811	0.3427	0.3485	0.2603	0.1360

	F mg/l	PO4 mg/l	Li mg/l	TURBIDY
F mg/l	1.0000			
PO4 mg/l	-0.1002	1.0000		
Li mg/l	0.7274	0.4503	1.0000	
TURBIDY	0.0243	0.5200	0.5523	1.0000

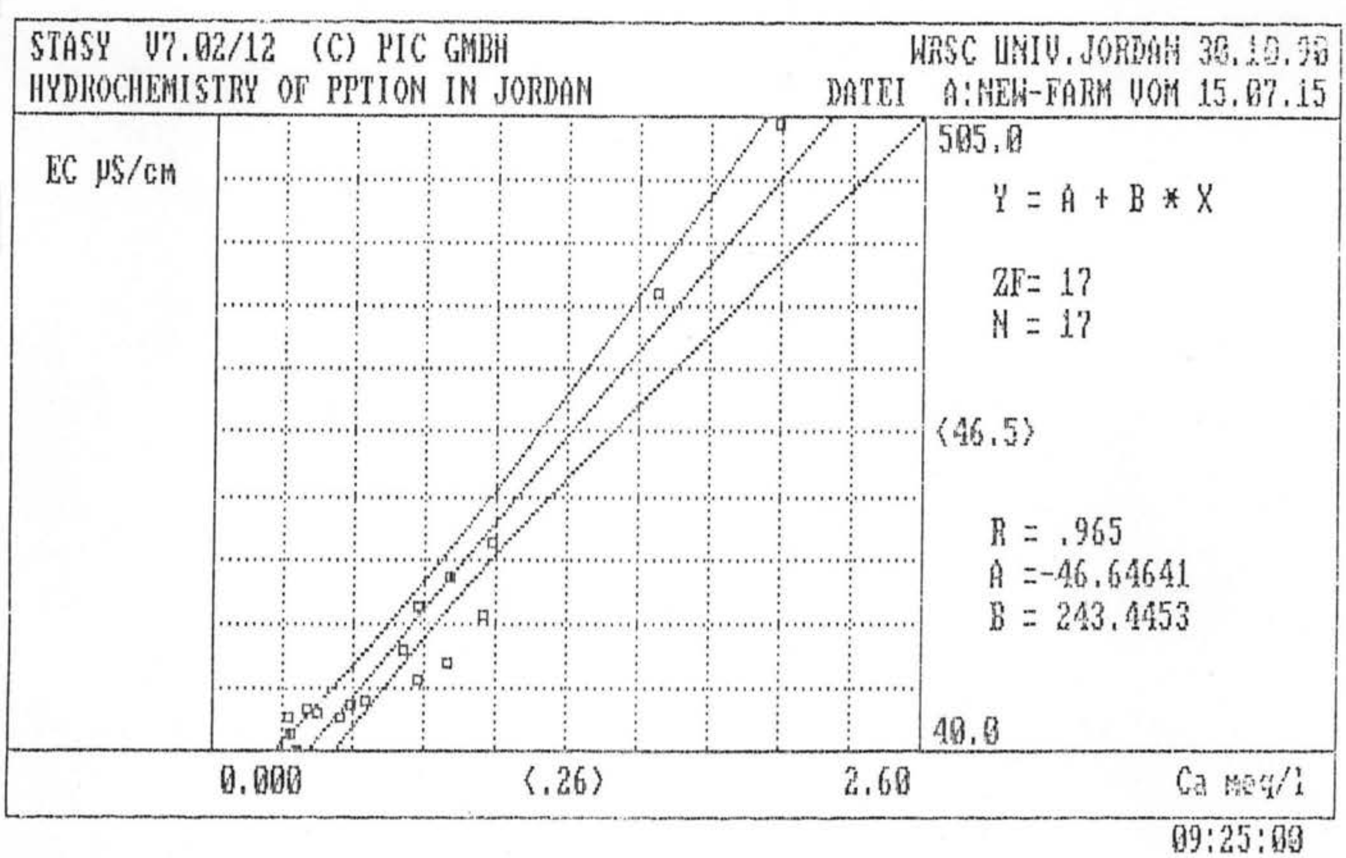
Table(21): Product Moment Correlation for University Farm Station

GEO-500 V1.01/P2 (C) PIC GMBH — WRSC / UNIVERSITY OF JORDAN / AMMAN
HYDROCHEMISTRY OF PPTION IN JORDAN — MUWAQQAR STATION
CORRELATION MATRIX

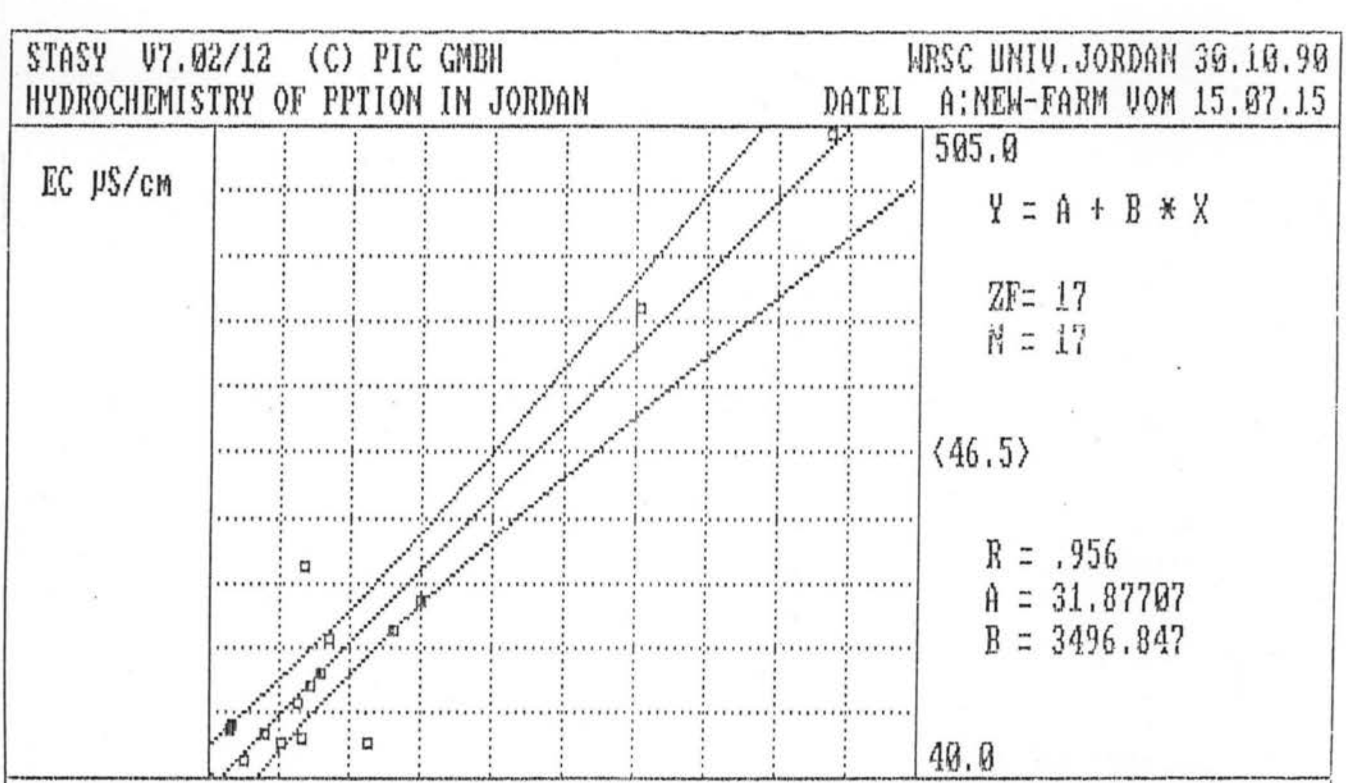
	DATE	pH VALUE	EC µS/cm	Na meq/l	K meq/l	Mg meq/l	Ca meq/l
DATE	1.0000						
pH VALUE	0.0141	1.0000					
EC µS/cm	0.5318	0.2640	1.0000				
Na meq/l	0.2293	0.4078	0.8190	1.0000			
K meq/l	0.3874	-0.0467	0.6764	0.6721	1.0000		
Mg meq/l	0.3431	0.0552	0.6805	0.6162	0.7223	1.0000	
Ca meq/l	0.5903	0.2027	0.9191	0.5715	0.4533	0.4248	1.0000
Cl meq/l	0.2663	0.0345	0.7309	0.7891	0.6195	0.6901	0.5172
NO3 meq/	0.4486	0.3117	0.6501	0.6404	0.3403	0.3620	0.5762
SO4 meq/	0.4961	0.1693	0.8224	0.4214	0.4053	0.4844	0.9074
HCO3 meq	0.5121	0.3959	0.9060	0.8122	0.6681	0.5412	0.8174

	Cl meq/l	NO3 meq/	SO4 meq/	HCO3 meq
Cl meq/l	1.0000			
NO3 meq/	0.4573	1.0000		
SO4 meq/	0.3348	0.4592	1.0000	
HCO3 meq	0.5370	0.5970	0.6643	1.0000

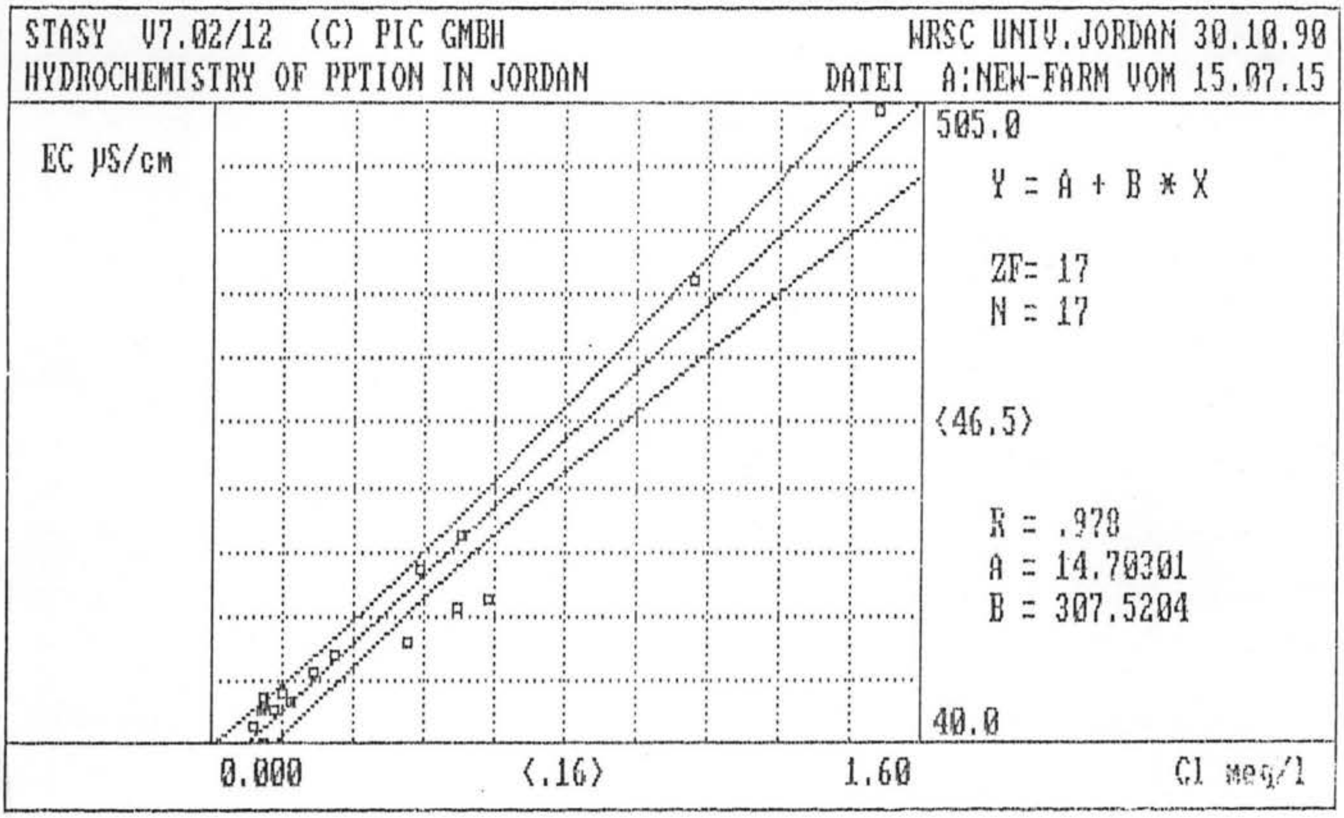
Table(22): Product Moment Correlation for Muwaqqar Station



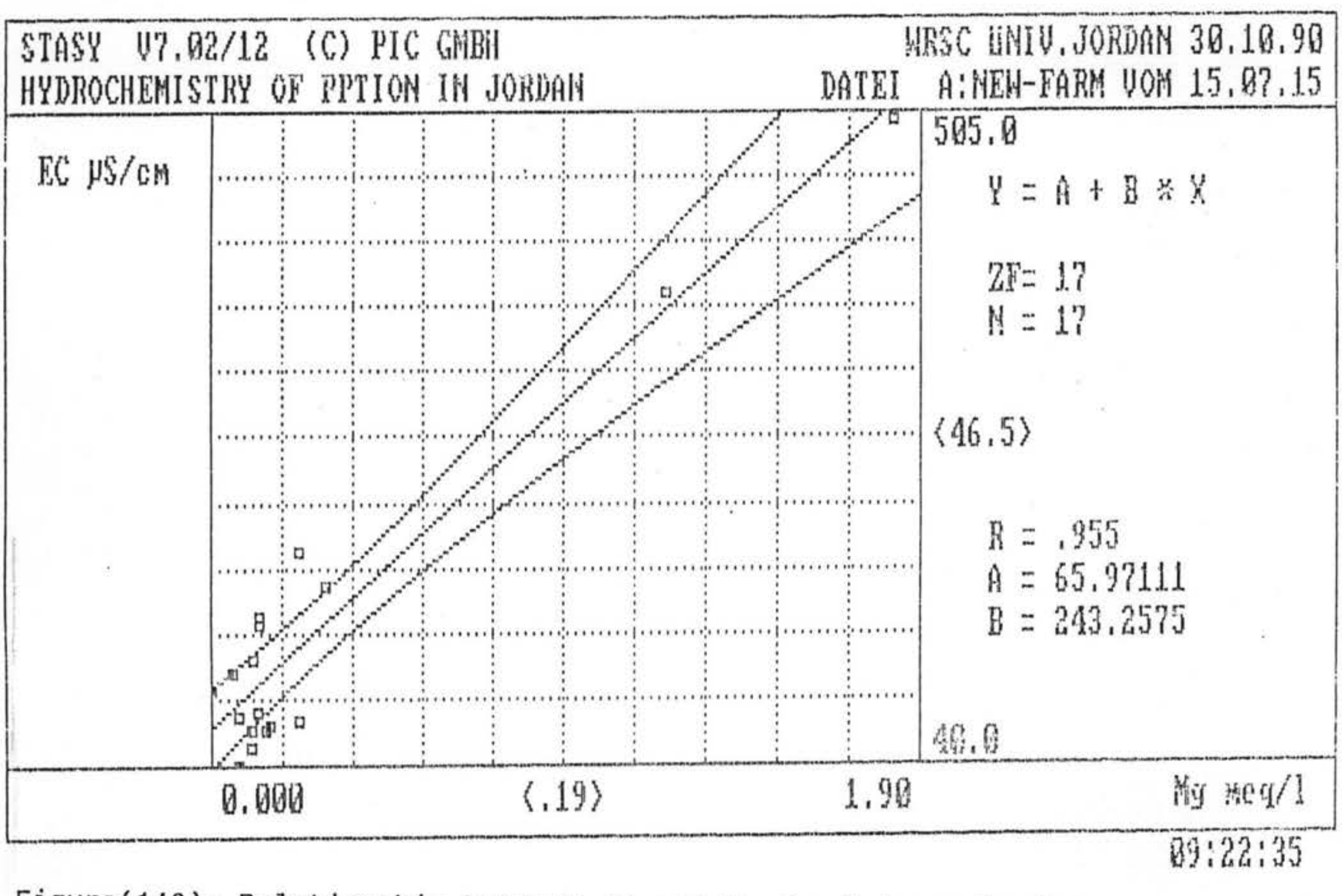
Figure(143): Relationship between EC and Ca for University Farm Station



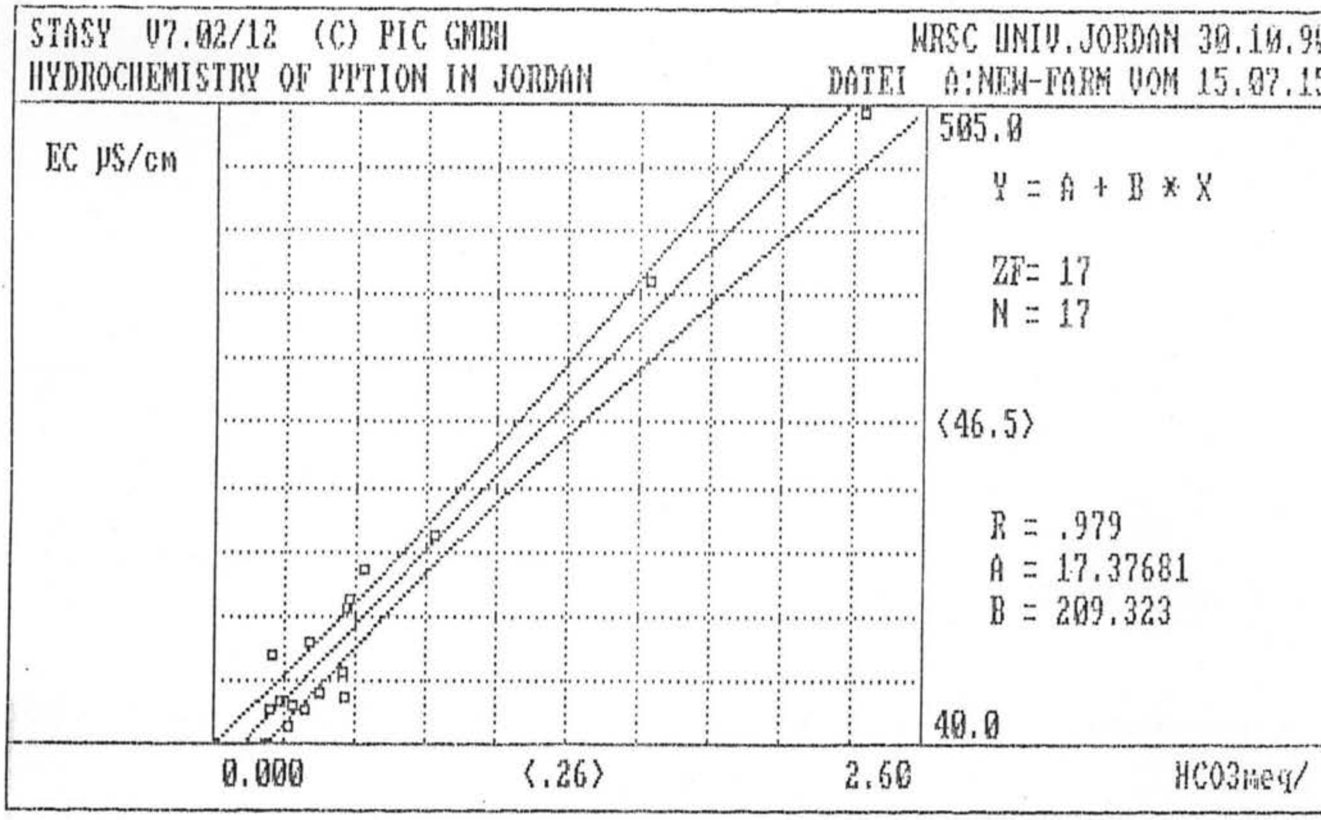
Figure(144): Relationship between EC and K for University Farm Station



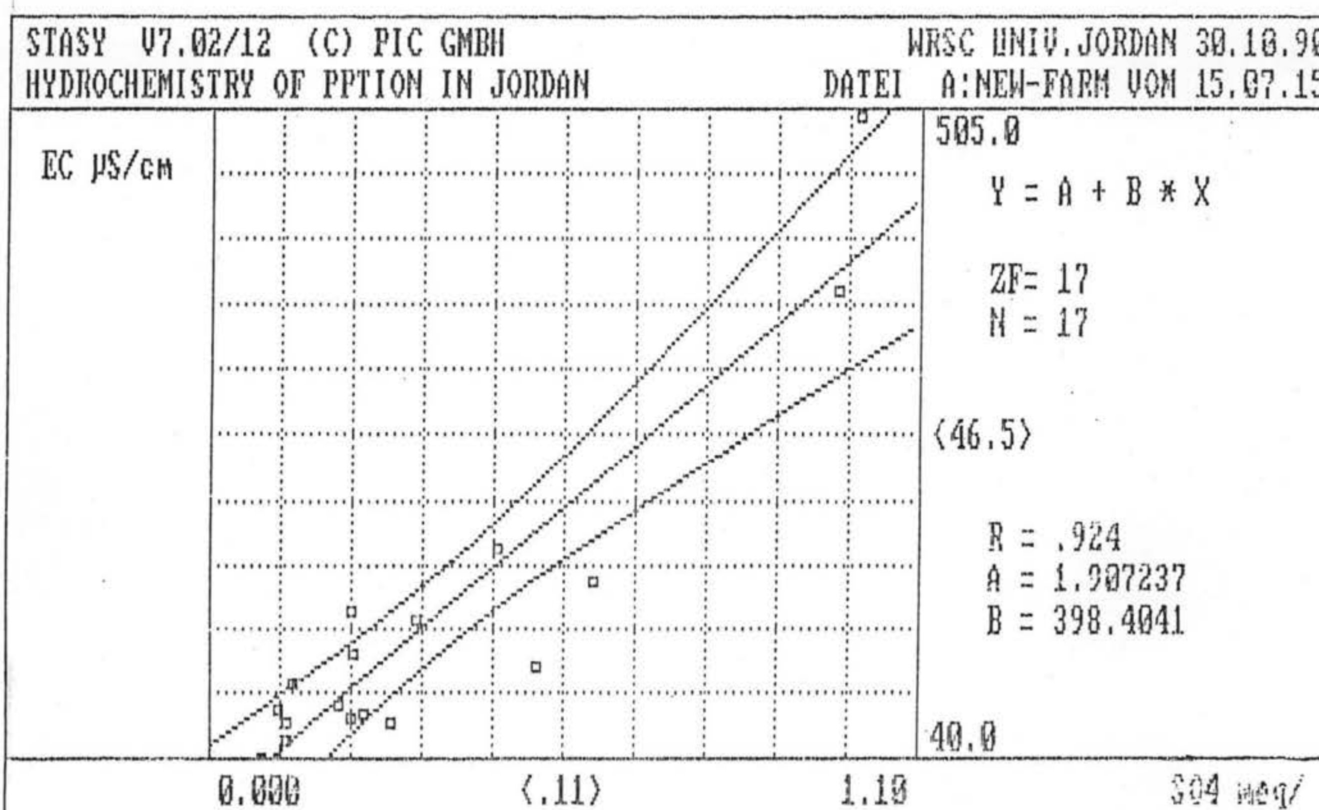
Figure(145): Relationship between EC and Cl for University Farm Station



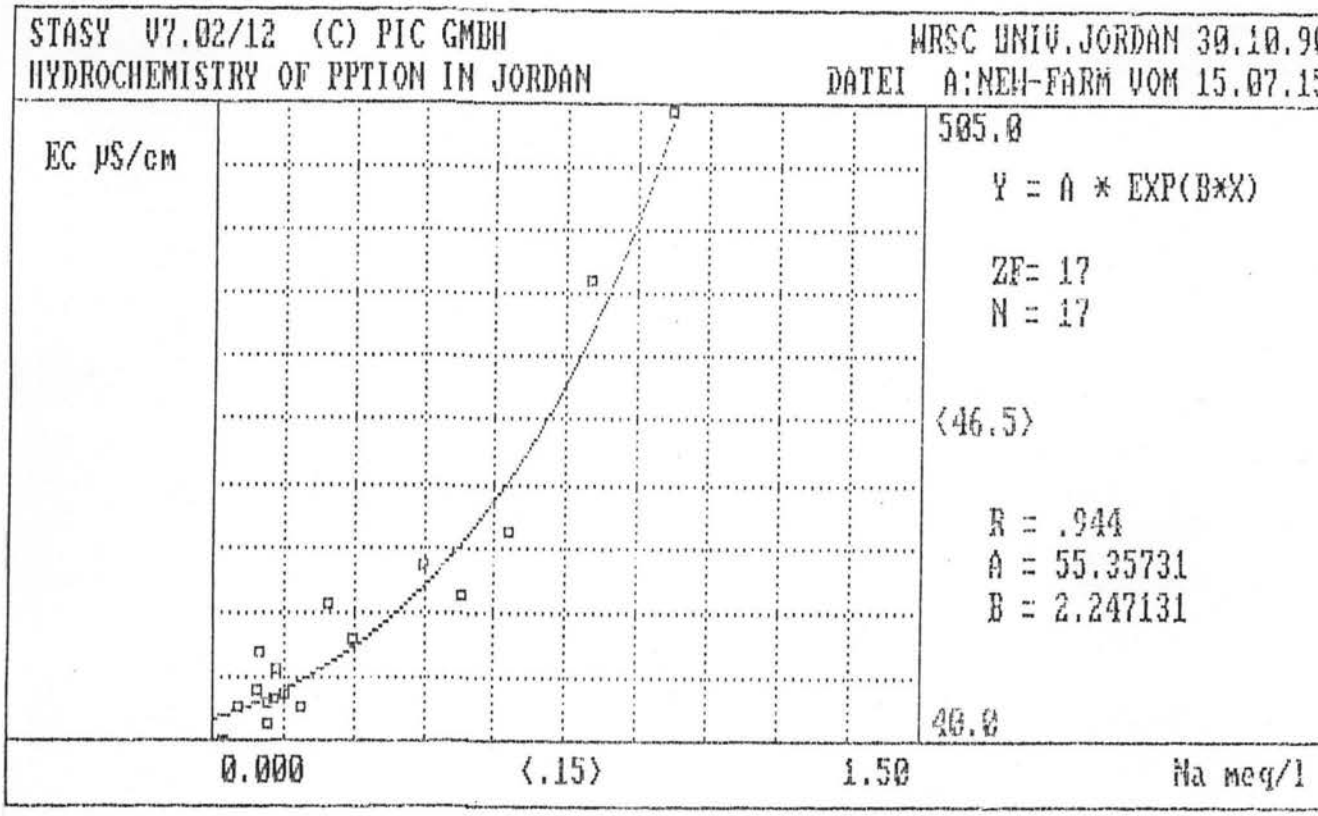
Figure(146): Relationship between EC and Mg for University Farm Station



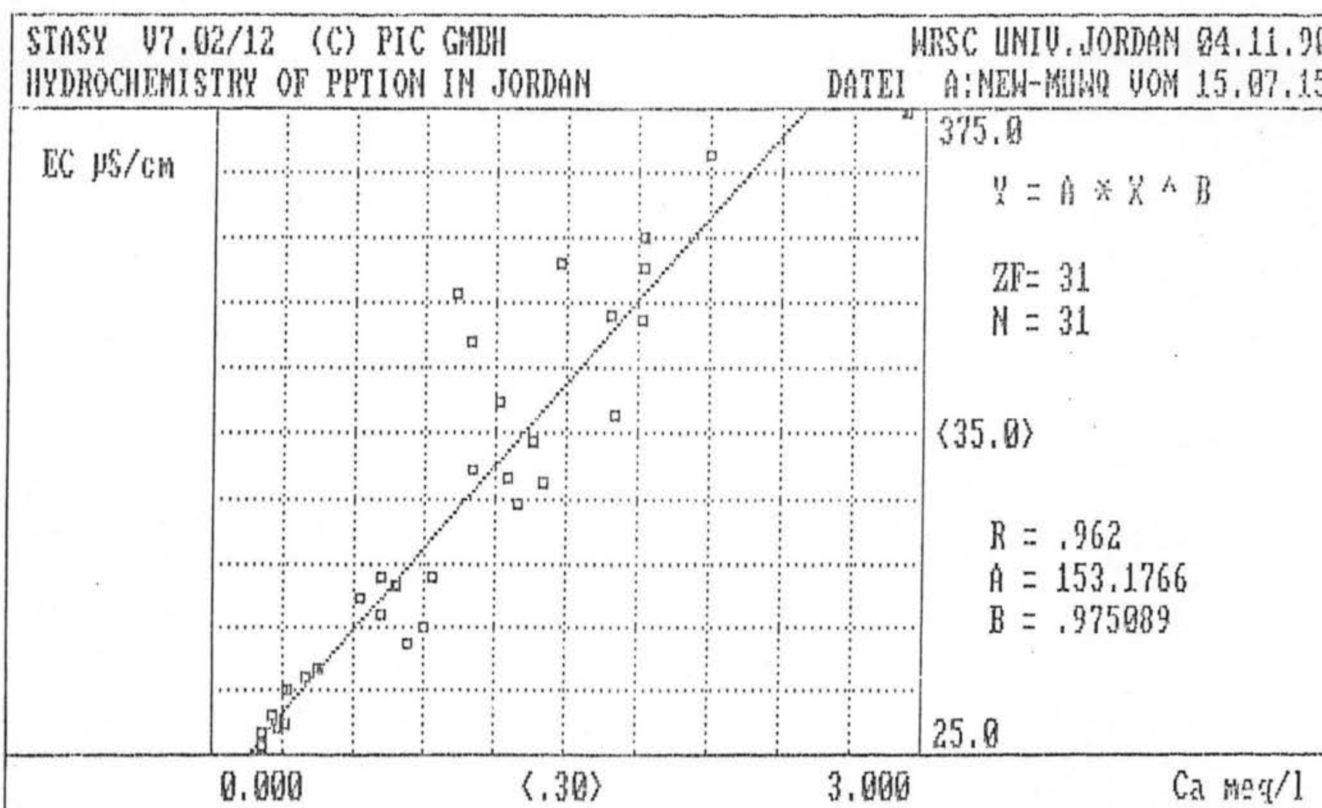
Figure(147): Relationship between EC and HCO_3 for University Farm Station



Figure(148): Relationship between EC and SO_4 for University Farm Station



Figure(149): Relationship between EC and Na for University Farm Station



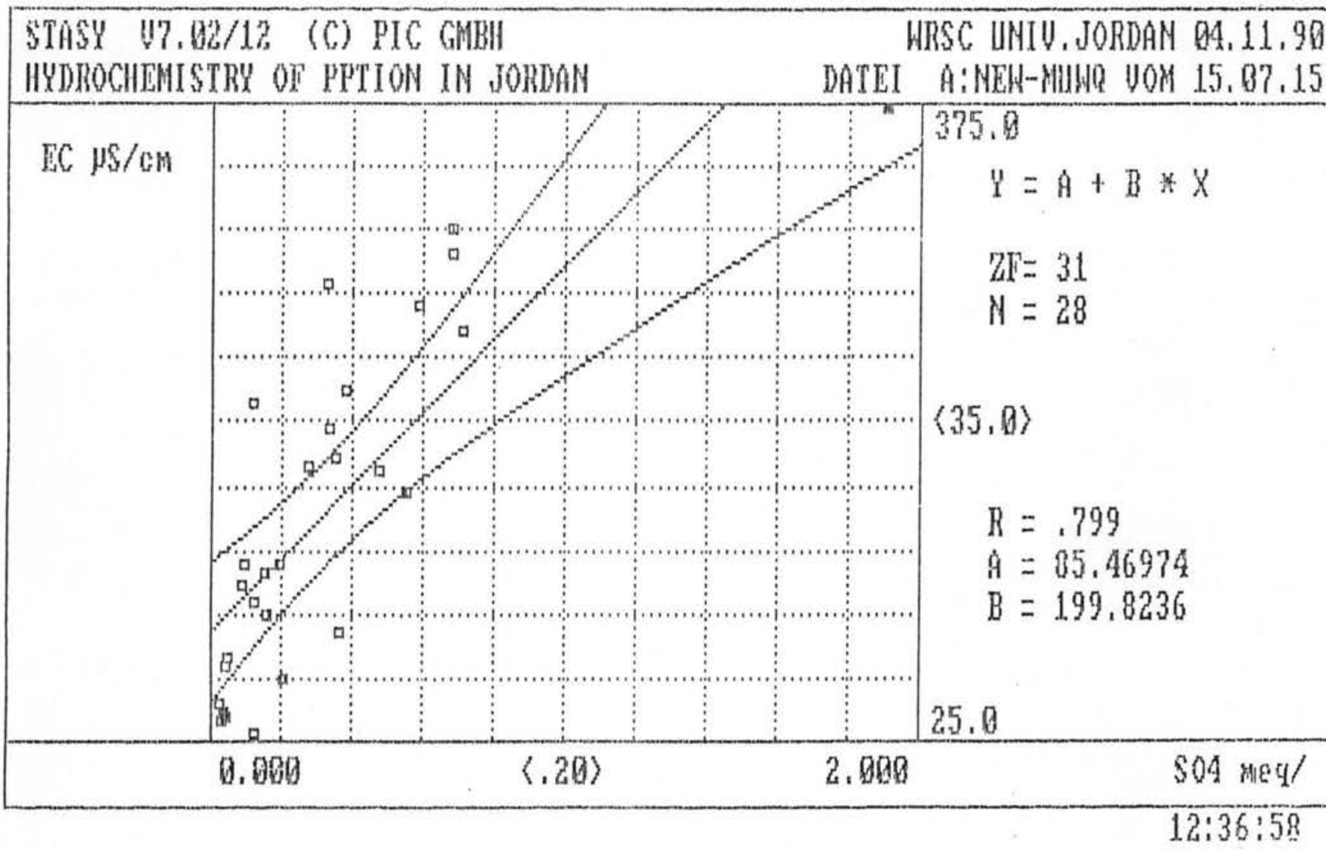
Figure(150): Relationship between EC and Ca for Muwaqqar Station are 0.919, 0.906, 0.822, 0.819, 0.731, 0.681, 0.676 and 0.650 respectively. Some of these relations are shown in figures (150, 151, 152 and 153). The dusty material constituting of calcite, dolomite, kaolinite, illite and traces of gypsum are the main sources of the different ions in the rain water precipitated in the area. The multisources of Ca ions in the water can be indicated by the relationship between EC and Ca which follows the following equation (figure 150).

EC μs/cm = 153.18 * [Ca meq/l]$^{0.975}$, r = 0.962

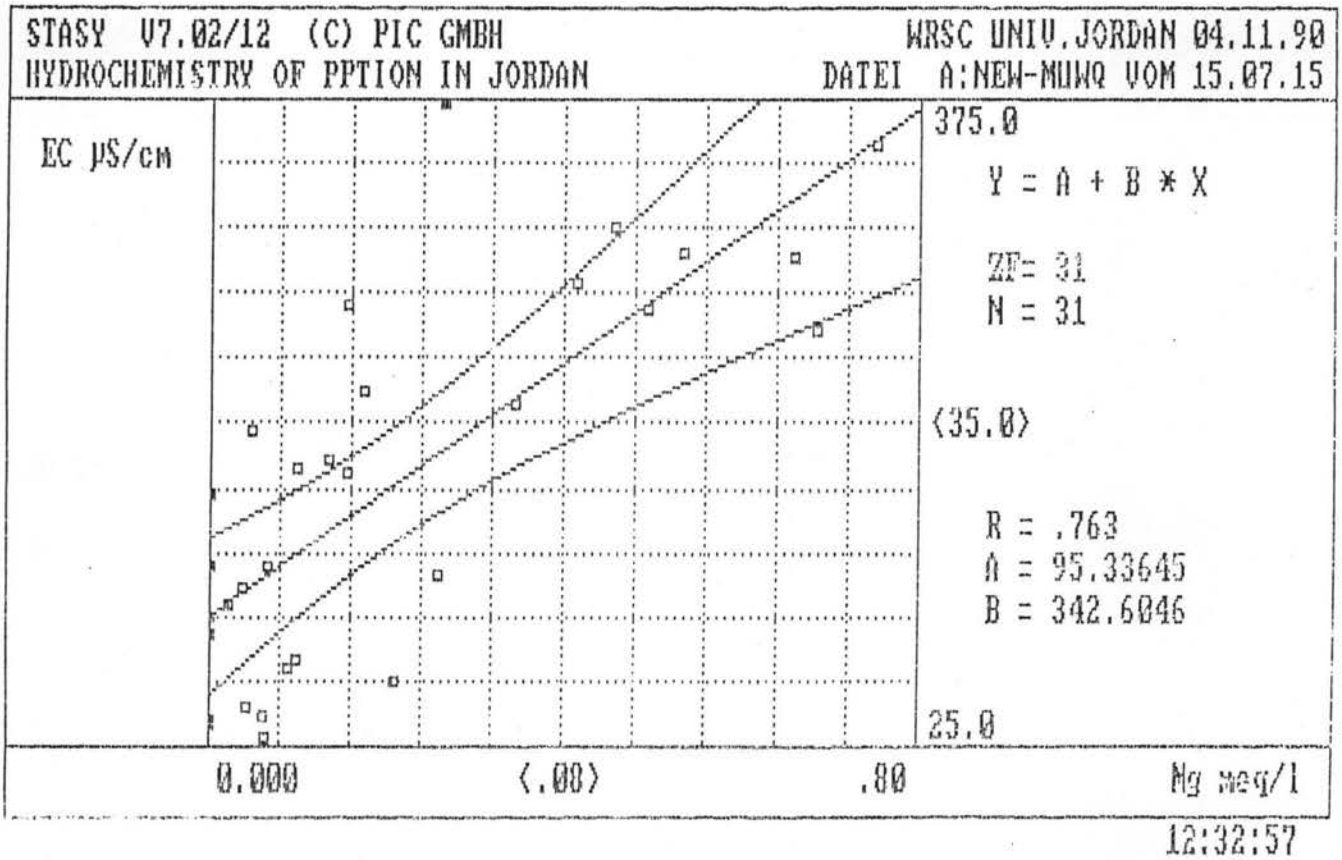
Dissolutional processes of calcite dolomite and gypsum are the main sources of Ca and at the same time the sources of Mg (dolomite) as well as sulfate (gypsum). The eastern winds (Khamasien winds), eastern as well as Red Sea depressions are the most prominent dust carrier to the area. But the Mediterranean and the polar depressions, especially those coming from the western direction and passing over the Dead Sea area, are responsible for the bromide, K, Na, Mg, and Ca contents in the rain water.

Nitrate contents in rain water samples collected from the area are attributed to the thunderstorms during intense rainfall in a dusty atmosphere.

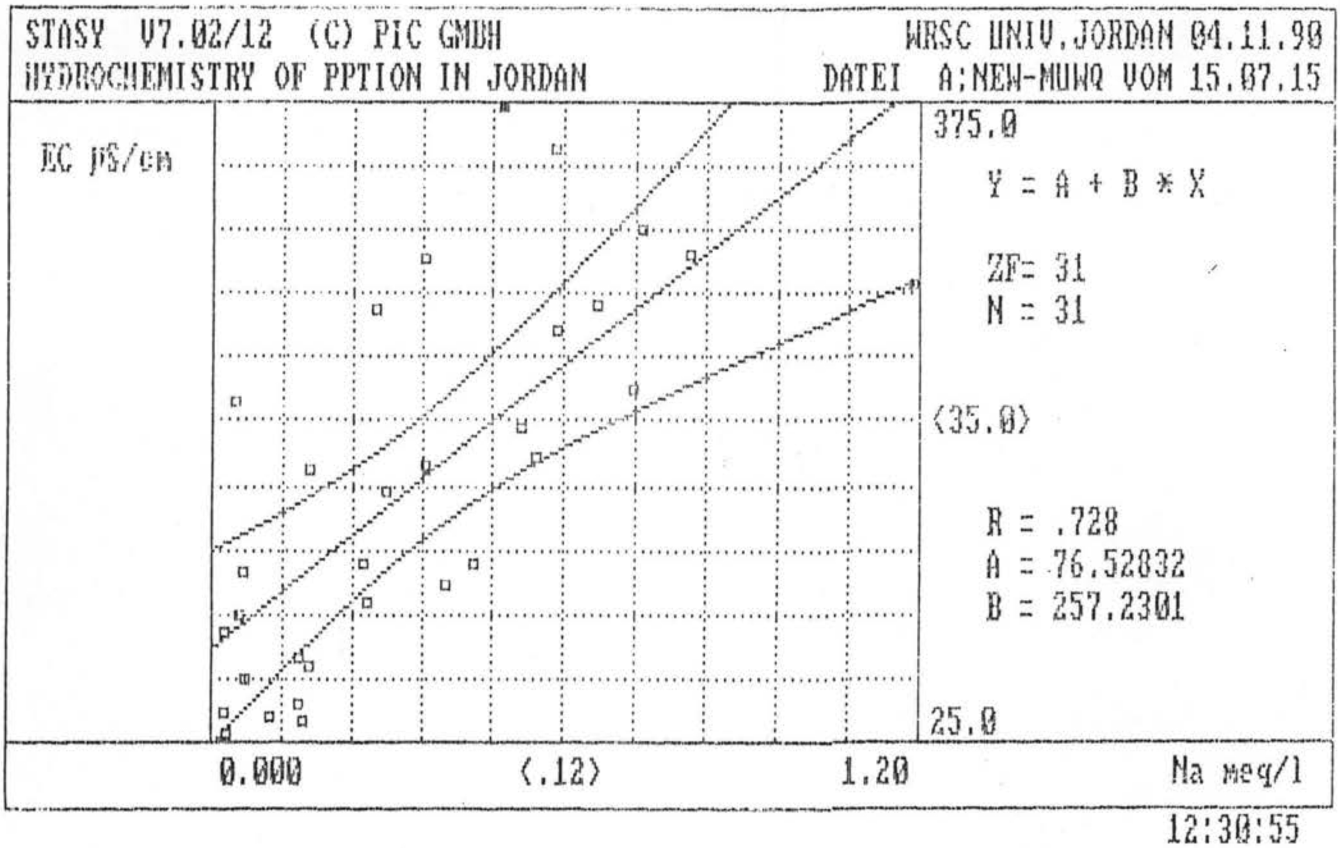
The above mentioned three conditions are approved by the first 5-factor loading of varimax rotation (table 23), where the first factor indicates the effect of dusty material in the atmosphere, the second factor explains the effect of Mediterranean and polar depressions on the rain water chemistry, the third factor explains the effect of the Dead Sea, factor four



Figure(151): Relationship between EC and SO_4 for Muwaqqar Station



Figure(152): Relationship between EC and Mg for Muwaqqar Station



Figure(153): Relationship between EC and Na for Muwaqqar Station

GEO-500 V1.01/P2 (C) PIC GMBH — WRSC /UNIVERSITY OF JORDAN / AMMAN
HYDROCHEMISTRY OF PPTION IN JORDAN — MUWAQQAR STATION
FACTOR LOADINGS - VARIMAX ROTATION

	FACT-1	FACT-2	FACT-3	FACT-4	FACT-5	FACT-6	KOMMUN.
SO4 meq/	0.9317						0.969
Ca meq/l	0.8785						0.984
EC µS/cm	0.6996	0.4308	0.3732	0.3774			0.998
K meq/l		0.7725	0.4898				0.931
HCO3 meq	0.5613	0.6309			0.3079		0.958
Na meq/l		0.6067	0.3843	0.5382			0.971
Mg meq/l			0.8988				0.971
Cl meq/l		0.3854	0.6172	0.5361			0.885
NO3 meq/				0.8213		0.3003	0.908
pH VALUE					0.9747		0.981
DATE	0.3289					0.8859	0.954
SS	2.8461	1.8640	1.8229	1.6241	1.2311	1.1206	10.509
% VA	25.8735	16.9454	16.5719	14.7648	11.1915	10.1874	95.535

Table(23): Factor Loadings for Muwaqqar Station explains the effect of thunderstorms and their contribution to salinity and the fifth factor shows the influence of pH on the HCO_3 content.

V- Isotopic Composition of Precipitation Water

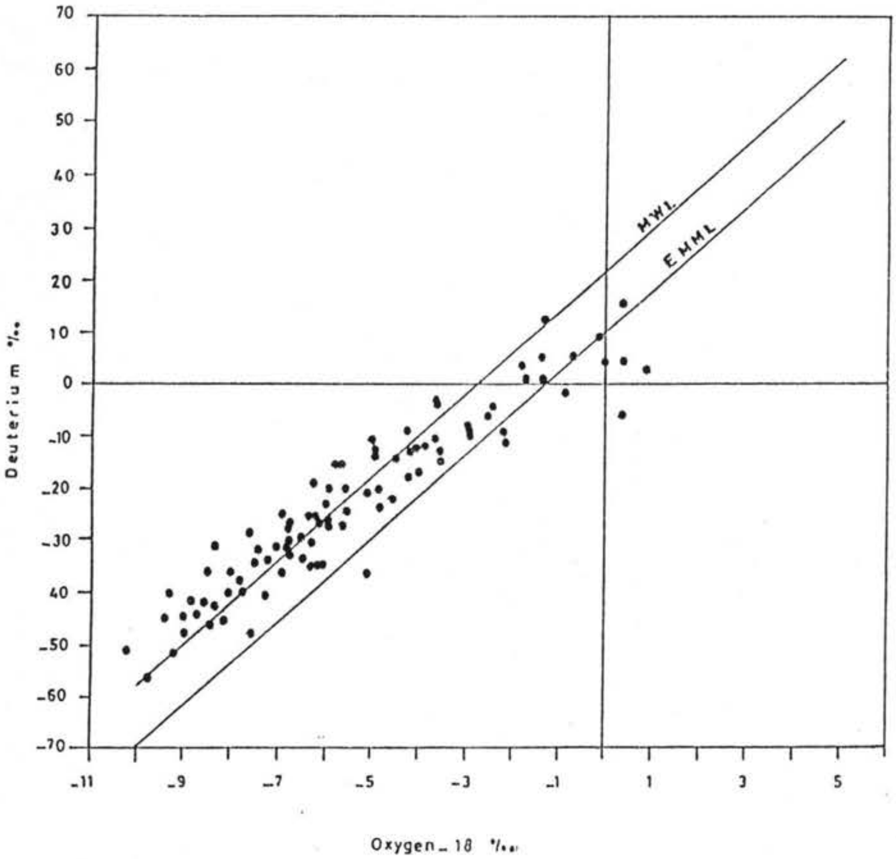
The isotopic composition of a water source gives valuable information about its history from the stage of evaporation through condensation ,precipitation and circulation within the water cycle. The isotopic composition of precipitation water facilitates practical studies concerned with the origin of water resources, their ages and exposure to evaporation or mixing processes. It also gives valuable information about the origin and history of precipitation water.

During its course from evaporation to precipitation ,the water is exposed to processes like condensation, reevaporation, precipitation and interception and reevaporation. The water vapor also rises and drops over mountain chains and morphological depressions, crosses cold and warm climates and either falls to the earth in quantities or in few amounts. All these factors affect the isotopic composition and the isotopic composition is one of the major tools to deliver information about the exposure of precipitation to one or more of there effects.

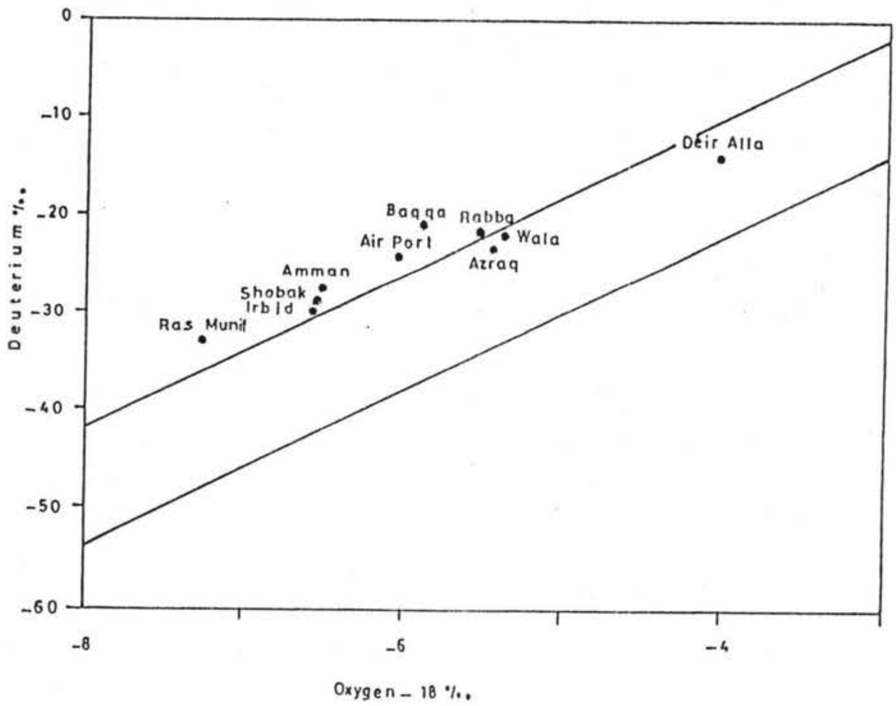
The analysed isotopes in precipitation water are :

1. Oxygen O^{18}
2. Deuterium H^2 = D
3. Tritium H^3 = T

The importance of O^{18} and H^2 lies in addition to their concentration, in their concentration ratios. Worldwide the concentration of both O^{18} and H^2 plots on a line called the Meteoric Water Line (MWL), where the concentrations of O^{18} and H^2 refer to a standard sample collected from the bottom of the ocean, figure (154).



Figure(154): δO^{18}-δD Relationship of All Collected Precipitation Samples



Figure(155): Isotope Ratios for the 10 Rainfall Stations

In the Eastern Mediterranean region the ratio of O^{18} and H^2 concentrations are found to fit on a special line called EMML, figure (154).

Whereas O^{18} and H^2 are stable isotopes of oxygen and hydrogen, tritium (H^3) is a radioactive isotope of hydrogen produced by the action of cosmic rays on atmospheric gases. The half life time of H^3 is 12.43 years. The relatively short half life of H^3 enables the age determination of a water source. Hence, its importance in the study of water resources.

In the last 4 to 5 decades nuclear tests caused great increase in the tritium concentration of the atmosphere which resulted in the disturbance of tritium use as a tool for hydrogeological studies.

Sampling and Analyses

Samples were collected and analysed by the laboratories of the Ministry of Water and Irrigation as a joint effort within a Master-Thesis prepared by Eng. William Bajjali under the cosupervision of Dr. Raja Gedeon the Director of Laboratories and Quality Control of the Ministry of Water and Irrigation.

Sample collection and analyses procedures followed those used by the International Atomic Energy Agency / Vienna.

Discussion of results

Isotopic composition

The general relationship between O^{18} and D for natural waters is linear and can be expressed by the following equation :

$$D = a \, \delta O^{18} + d$$

Where a : is the slope

d : is the intercept

The relationship between δO^{18} and D of precipitation in Jordan for all available samples from all stations is given in figure (155). The arithmetic mean, weighted mean values and the weighted mean values of samples having precipitation of more than 10 mm are listed in table (24). The weighted mean value for each station, given in figure 155, shows that the isotopic composition more or less fits the EMML except for Deir Alla, Azraq, Rabba and Wala stations which deviate a little from the line. The high altitude stations; Shobak and Ras Munif plot at the beginning of the EMML while the lower altitude station; Deir Alla plots its end. The low slope for the unweighed mean, may indicate that intense rain, which dominates the weighted mean, originates, from vapour released from sea water (Mediterranean) in a very fast evaporation process. Furthermore, the low value of the d-parameter could be as a result of the relatively low mean condensation temperature of the heaviest rain.

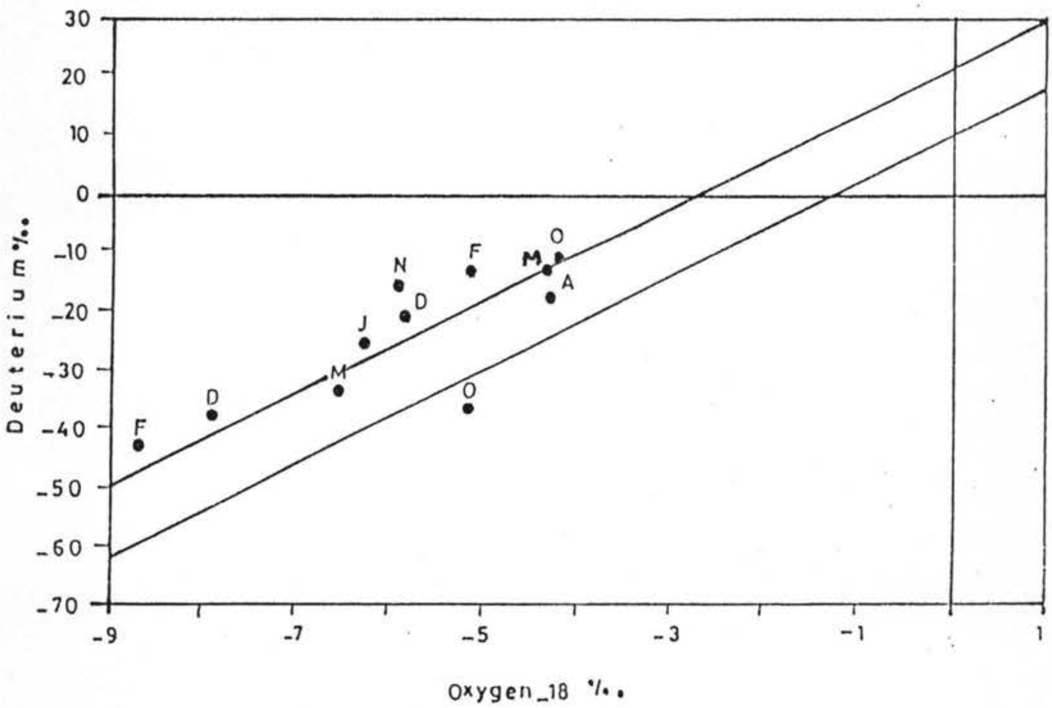
The isotopic composition of the 11 rainfall stations scatter relative to the MWL and to the EMML; which indicates that the different rain stations are differently affected by the various parameters such as cooling, condensation outraining etc.

The D - δO^{18} diagrams for the 10 rainfall stations in Jordan are shown in figures 156 through 165. The most commonly encountered situation is that of deuterium excess; d-parameter more than 10 o/oo. The high d-parameters persists in rain throughout Jordan and is actually regarded as identifier for the Eastern Mediterranean area. These features of the isotope

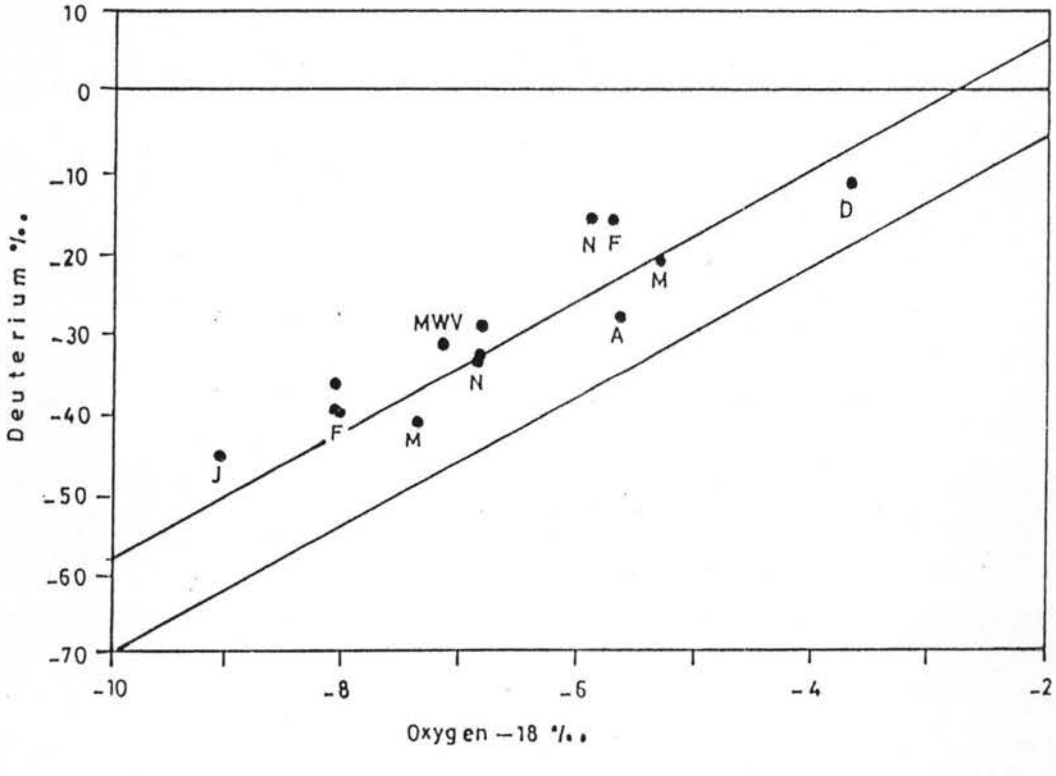
Name	Date	MWV			MWV > 10 mm	
		0-18	Deuterium	Tritium	0-18	Deuterium
		o/oo	o/oo	T.U	o/oo	o/oo
zraq	12.87-5.88	-5.35	-26.62	13.02	-5.55	-27.43
Azraq	12.88-5.89	-4.15	-13.91	9.08	-4.22	-14.35
Azraq	10.67-5.68	-4.41	-19.53		-6.63	-29.15
Average		-4.64	-20.02		-5.47	-23.64
Irbid	11.87-4.88	-7.16	-32.74	8.34	-7.19	-33.01
Irbid	10.88-3.89	-6.09	-24.37	8.11	-6.13	-24.68
Irbid	11.65-3.66	-6.03	-27.81	234.62	-6.03	-27.81
Irbid	10.66-4.67	-6.97	-33.11	106.04	-7.02	-33.28
Average		-6.56	-29.51		-6.59	-29.70
Rabba	12.88-4.88	-7.47	-33.24	23.11	-7.47	-33.24
Rabba	12.88-3.89	-5.91	-22.50	16.11	-5.91	-22.50
Rabba	12.65-3.66	-5.71	-25.14	203.19	-5.71	-25.14
Rabba	10.66-3.67	-2.54	- 7.79	109.57	-3.96	-13.21
Rabba	11.67-4.68	-3.91	-10.85		-4.96	-15.05
Average		-5.11	-19.90		-5.60	-21.03
Shobak	12.87-4.88	-7.71	-36.48	8.92	-7.74	-36.51
Shobak	12.88-3.89	-6.19	-24.54	8.74	-6.19	-24.54
Shobak	12.65-3.66	-6.38	-31.68	203.32	-6.46	-32.42
Shobak	10.66-4.67	-5.96	-22.97	129.33	-5.98	-23.06
Average		-6.56	-28.92		-6.59	-29.13
Amman	10.87-3.88	-7.31	-33.41	11.19	-7.31	-33.41
Amman	12.88-3.89	-5.94	-12.06	9.82	-5.94	-21.06
Amman	11.65-3.66	-6.04	-27.11	233.03	-6.04	-27.11
Amman	10.66-3.67	-7.23	-31.21	115.59	-7.38	-31.57
Amman	11.67-5.68	-5.69	-21.66	58.12	-5.80	-22.35
Amman	10.68-4.69	-6.63	-31.85	83.41	-6.66	-32.08
Average		-6.47	-27.72		-6.52	-27.93
Baqqa	10.87-4.88	-6.65	-30.91	9.76	-6.67	-31.13
Baqqa	10.88-3.89	-5.05	-11.58	8.51	-5.13	-11.89
Average		-5.85	-12.25		-5.90	-21.51
Ras Munif	10.87-4.88	-7.65	-35.84	8.66	-7.65	-35.84
Ras Munif	11.88-3.89	-6.86	-30.55	9.14	-6.86	-30.55
Average		-7.26	-33.20		-7.26	-33.20
Deir Alla	12.87-3.88	-5.24	-21.67	10.29	-5.24	-21.67
Deir Alla	10.88-2.89	-2.84	- 6.43	10.06	-2.88	- 6.63
Average		-4.04	-14.05		-4.06	-14.15
Wala	12.87-4.88	-6.16	-26.23	15.83	-6.29	-26.89
Wala	12.88-3.89	-4.54	-17.91	10.67	-4.54	-17.91
Average		-535	-22.07		-5.42	-22.40
Q.A.Airp.	10.87-4.88	-6.25	-26.29	11.03	-6.63	-27.97
Q.A.Airp.	12.88-3.89	-5.47	-20.85	8.55	-5.47	-20.85
Average		-5.86	-23.57		-6.05	-24.41

MWV : Mean Weighted Value .
MWV > 10 mm : Mean Weighted Value > than 10 mm .

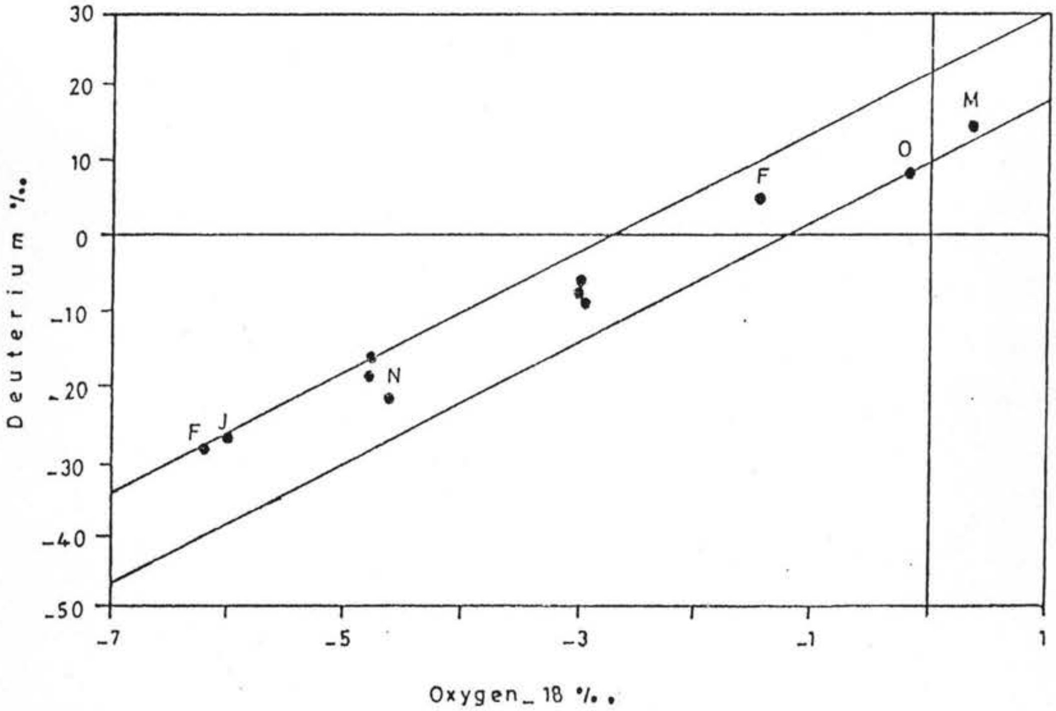
Table(24): Mean Weighted Value for All Samples



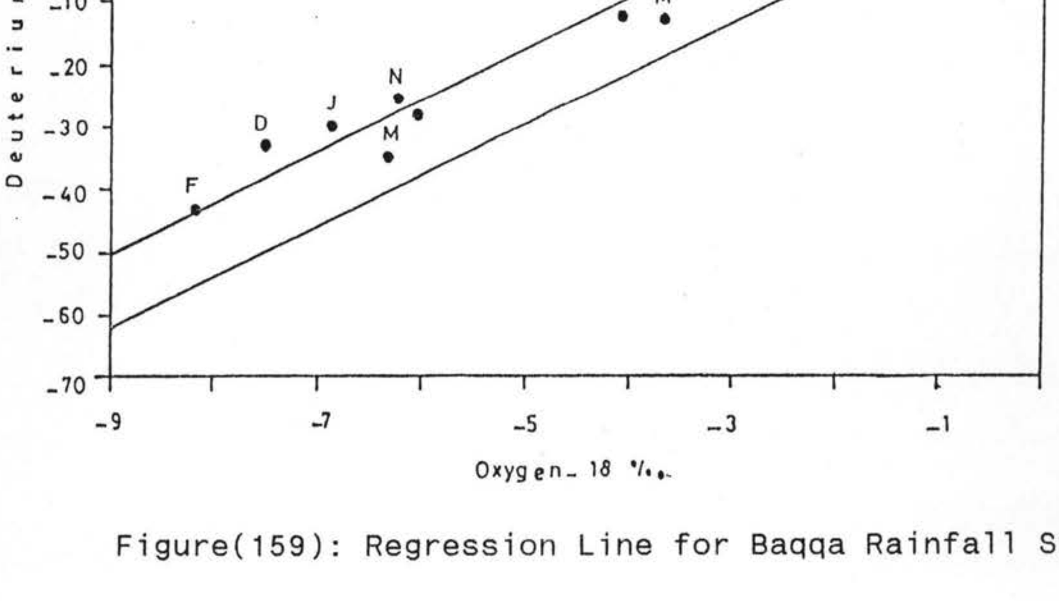
Figure(156): Regression Line for Irbid Station



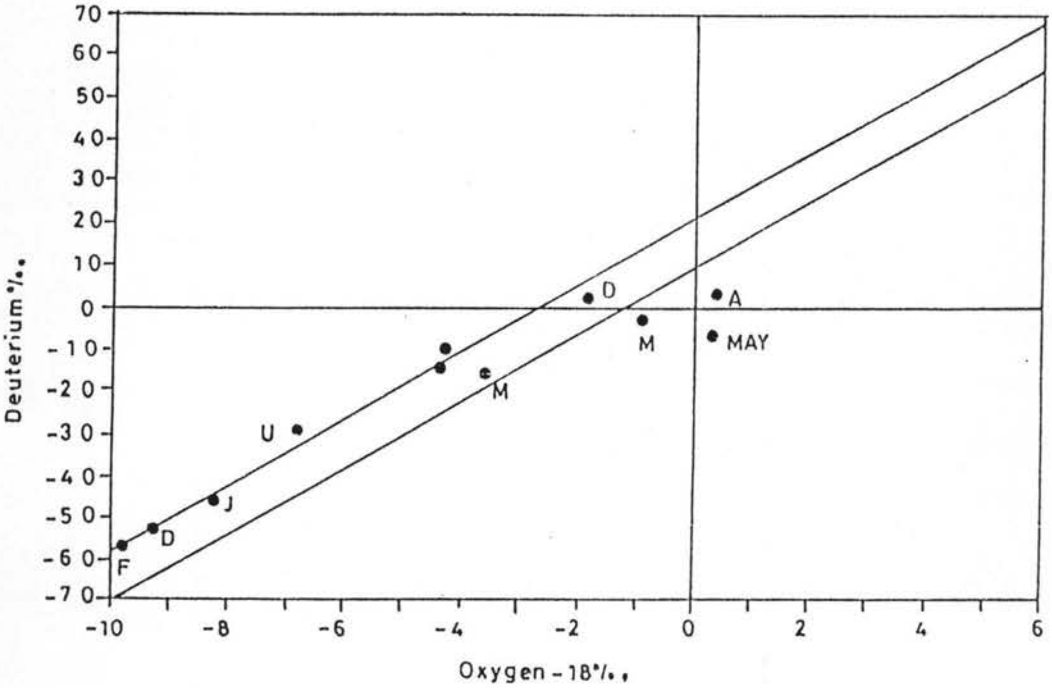
Figure(157): Regression line for Ras Munif Rainfall Station



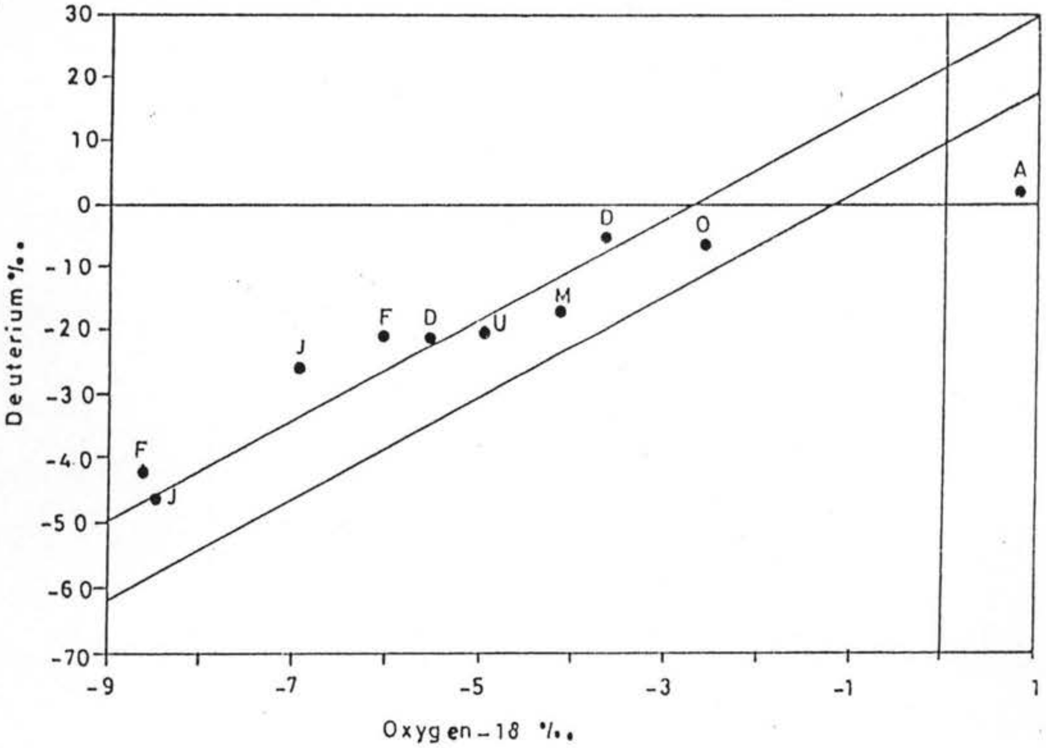
Figure(158): Regression Line for Deir Alla Rainfall Station



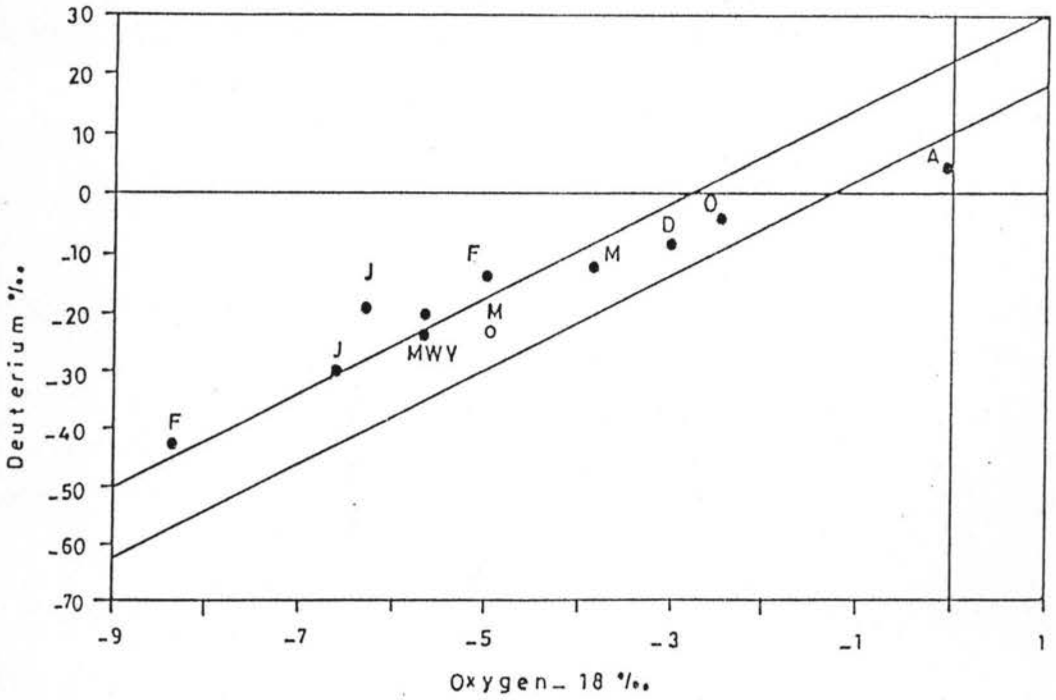
Figure(159): Regression Line for Baqqa Rainfall Station



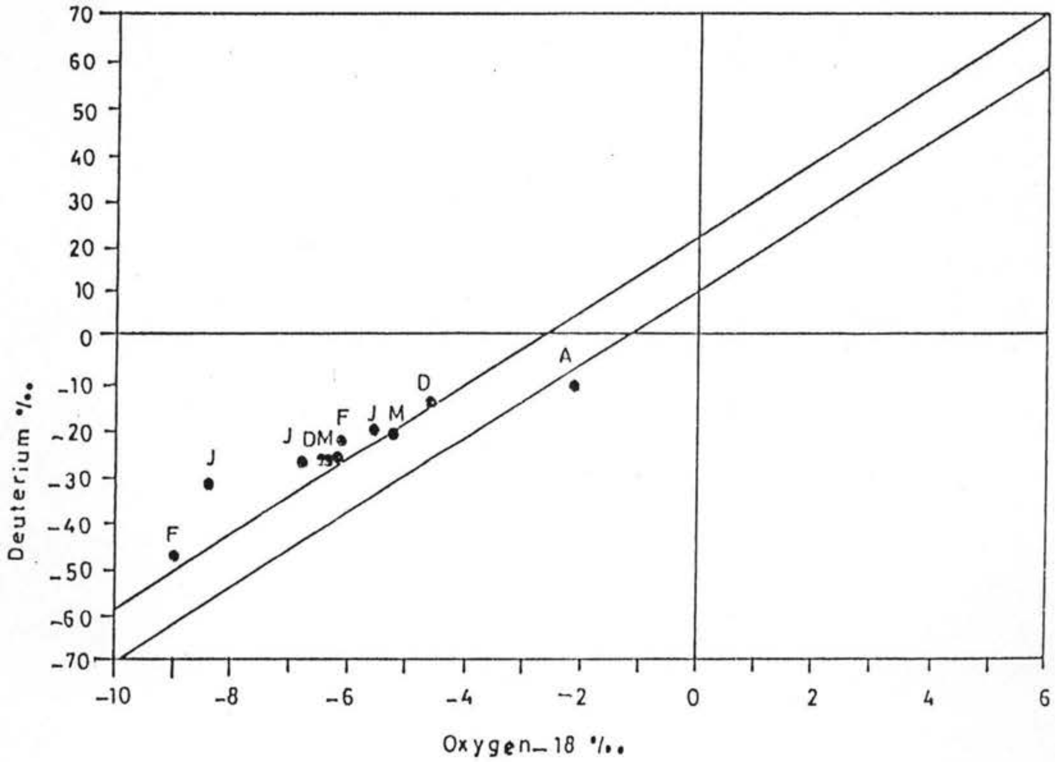
Figure(160): Regression Line for Azraq Rainfall Station



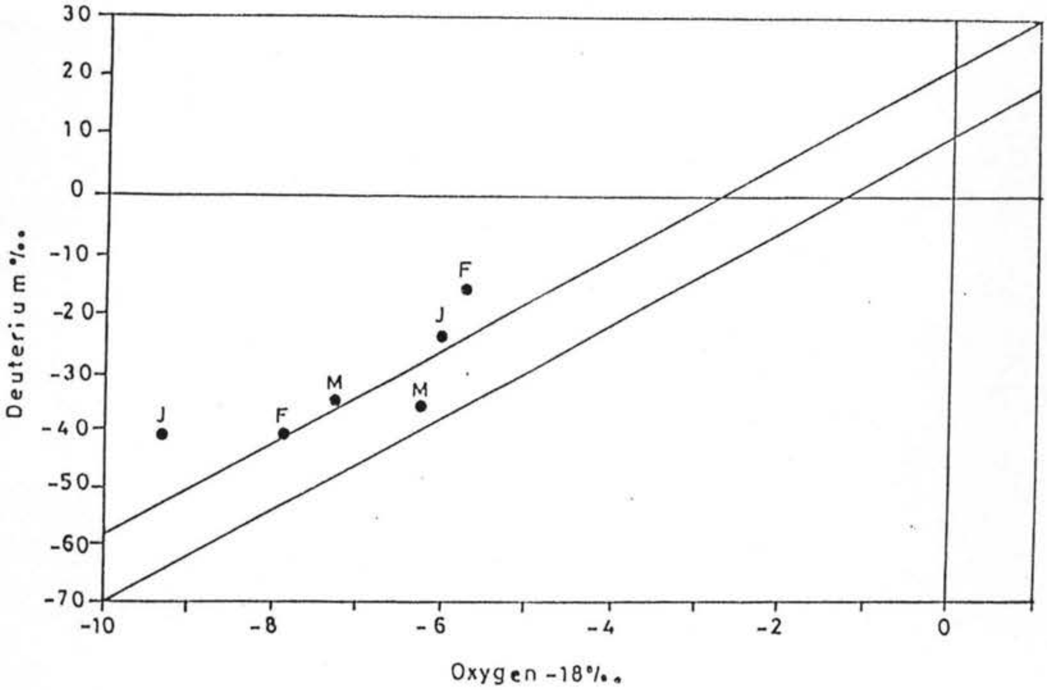
Figure(161): Regression Line for QAIA Rainfall Station



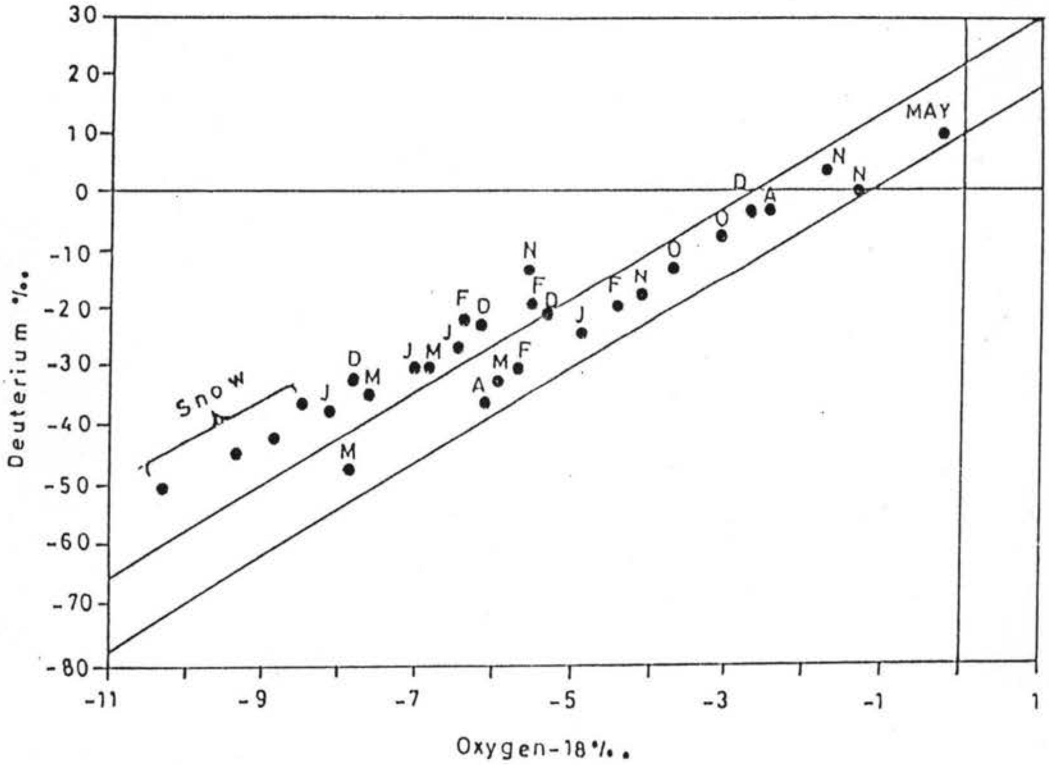
Figure(162): Regression Line for Wala Rainfall Station



Figure(163): Regression Line for Rabba Rainfall Station



Figure(164): Regression Line for Shobak Rainfall Station



Figure(165): Regression Line for Amman Rainfall Station distribution give rise to a model which is based on the air mass movement into the Mediterranean area during winter, when cold and dry continental air masses come in contact with warm sea, resulting in rapid evaporation and large scale convergence. Figures 156 to 165, show the isotope composition of monthly precipitation samples of the 10 rainfall stations.

The most divergent values, usually enriched in both oxygen-18 and deuterium, are those of months with deficient rainfall, (October, March, April and May). The spatial variation of the mean isotope content for all the rainfall station indicate that the measurements are scattered and cluster along lines of a slopes less than 8.

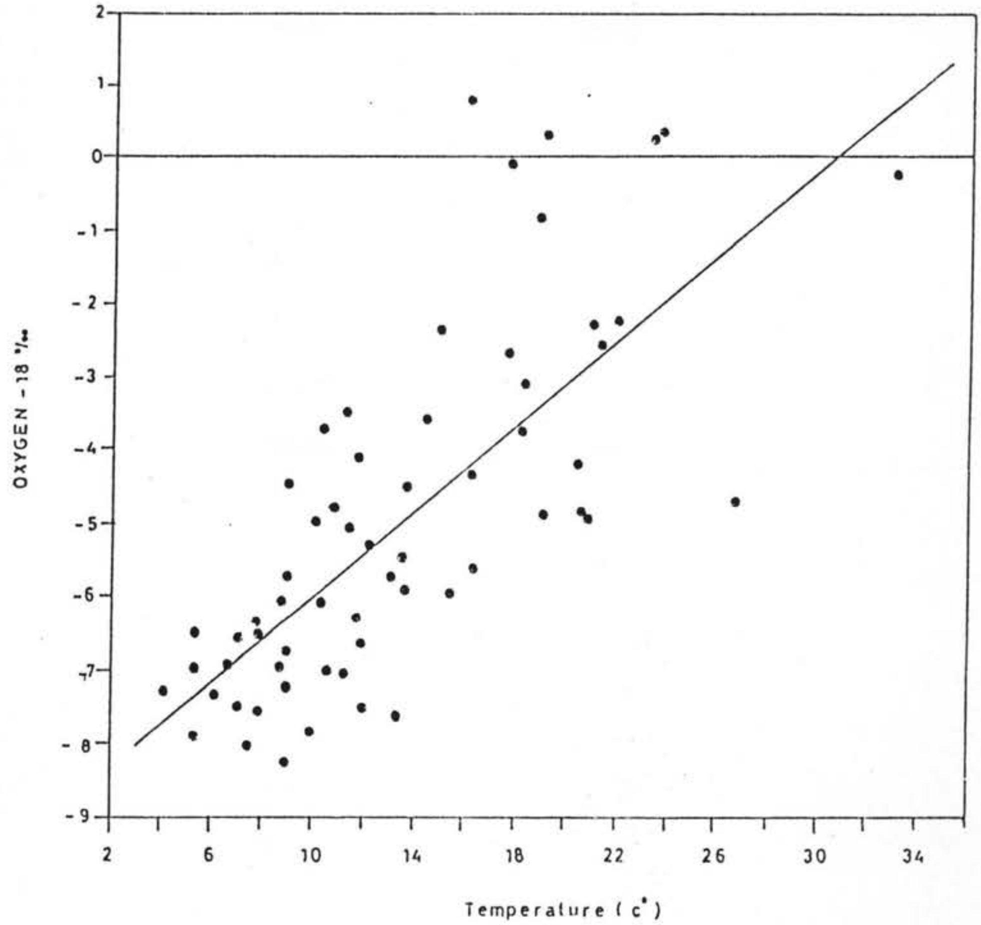
Table (25) shows the slopes, intercept, R and number of samples of the δO^{18} - δD for all the rainfall stations in the period of 1987-1989.

The isotopic composition of precipitation from mountain stations (Shobak and Ras Munif) describe a line of slope (5.39) and (6.89) respectively, whereas the values of rain collected at lower elevations (Amman and Baqa) = (6.68) for Deir Alla (6.59) and Azraq (5.68). The ratio of the isotopic composition of rain differs with increasing distance from the Jordan Rift Valley along various topographic sections. A continuous depletion of the heavy isotopes in the air masses during their ascent and passage over the Western Highland Mountains is observed.

Rain in Deir Alla,the lower lying station is more enriched in heavy isotopes, the d-value (12.15 o/oo) is less than at the mountain station lying just to the east of Deir Alla & Ras Munif

Table (25) : Slope, Intercept, R-Squared, Number of Samples and Deuterium Excess of the Period (1987-1989).

Stations	Slope	Intercept	R-Squared	Samples Number	d
Azraq	5.68+0.64	4.56+7.49	0.90	10	14.84
Irbid	6.41+1.23	12.91+6.4	0.71	13	22.64
Rabba	4.81+0.77	3.97+4.39	0.85	9	23.53
Shobak	5.39+1.79	5.84+4.05	0.60	8	23.91
Amman	6.25+0.47	13.97+4.05	0.94	13	26.08
Baqa	6.68+1.07	15.44+7.93	0.78	13	21.92
Ras Munif	6.89+0.95	16.76+4.67	0.83	12	24.10
Deir Alla	6.59+0.29	12.15+1.98	0.98	9	16.72
Wala	5.43+0.57	6.61+4.1	0.92	10	19.56
Q.A.Airport	5.10+0.66	5.42+0.66	0.88	10	19.97



Figure(166): Relationship Between the Surface Teperature at the Station and Oxygen 18 for the 10 Stations

(16.77 o/oo). This effect presumably results from the changes in cloud composition which accompany the passage of air masses over the Jordan Rift valley to the Eastern Highlands and also from the partial evaporation of falling droplets over Azraq and Deir Alla areas.

The precipitation samples of February 1988 include snow from Amman figure (165). These samples are very depleted in heavy isotopes, and show the highest value of the deuterium in excess of d = 30.7 o/oo. Snow, being a solid, will not change its composition during its descent to the ground and can thus serve as a monitor of cloud composition.

Rain samples collected from other stations in the same month show lower d-values during January and February (higher than 22 o/oo). Some times the d-values were: 35.44 o/oo in Rabba, 34.24 o/oo in Shobak, 32.4 o/oo in Amman, 30.72 o/oo in Wala and 30.14 o/oo in Queen Alia Airport Stations.

Variations in isotopic composition and their relations to other parameters.

The variations in the isotopic composition of precipitation in a rainfall station is a function of several parameters like topography, temperature, distance from oceans, elevation, origin of moisture ... etc.

These variations correlate also with other parameters of the precipitation itself like Electric Conductivity, pH, Calcium and Carbonate concentrations.

Temperature

Since precipitation is a result of cooling processes and since the isotopic composition of precipitation is a function of temperature, there should be a certain correlation between the isotopic composition and the temperature of precipitation formation. This temperature is not available but somehow correlates with the surface temperature at the station receiving precipitation.

Figure 166, shows correlation of O^{18} -values and the mean temperature at the station receiving precipitation.

The correlation coefficient of 0.55 indicates that the above made assumption can only partly explain the O^{18} - values and/or that other parameters affect these values. The weighted mean of O^{18}-values for each single station shows different temperature effects. The highest effect was found for Ras Munif (R^2 = 0.87) rainfall station and the lowest for Deir Alla (R^2 = 0.37). That could be explained by the fact that air masses having a particular isotopic composition entering the Jordan Rift Valley cause evaporation of rain droplet before falling to the surface. The air masses ascending along the highlands cause condensation by orographic effects.

Amount of precipitation

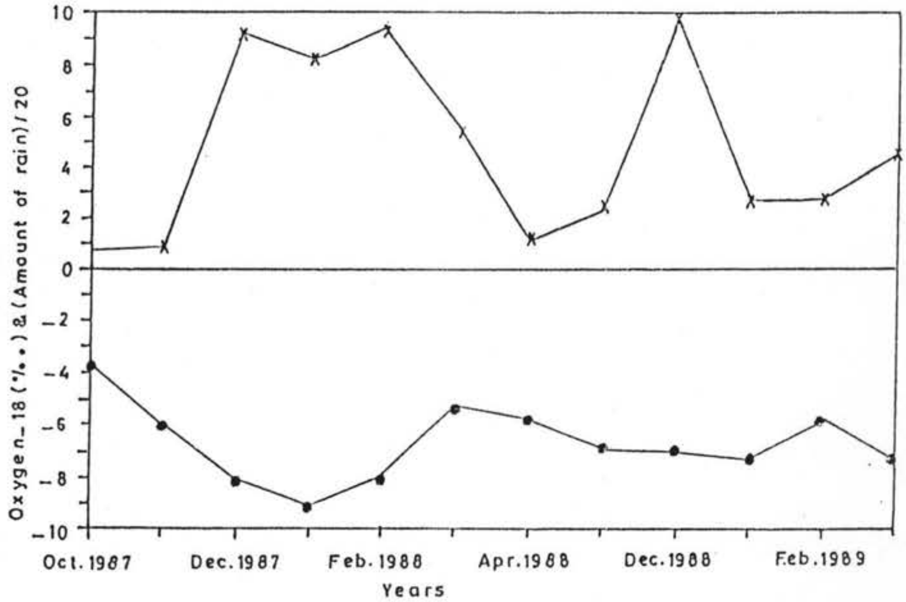
A slight enrichment in the heavy isotopes on months with small amount of rain can be observed. Some intense rain events are more depleted in their isotopic values. Examples of this are shown in figures 167A to 167F, where the time variation curves of δO^{18} monthly precipitation and δO values are plotted for the following six rainfall stations : Ras Munif, Irbid, Deir Alla, Amman, Wala and Rabba. These stations show better correlation of $R^2 = 0.64$ and $R^2 = 0.55$, whereas Shobak and Azraq stations don't show any correlation. This could be explained by the different origins of rains and the dust effects.

Variations with elevation

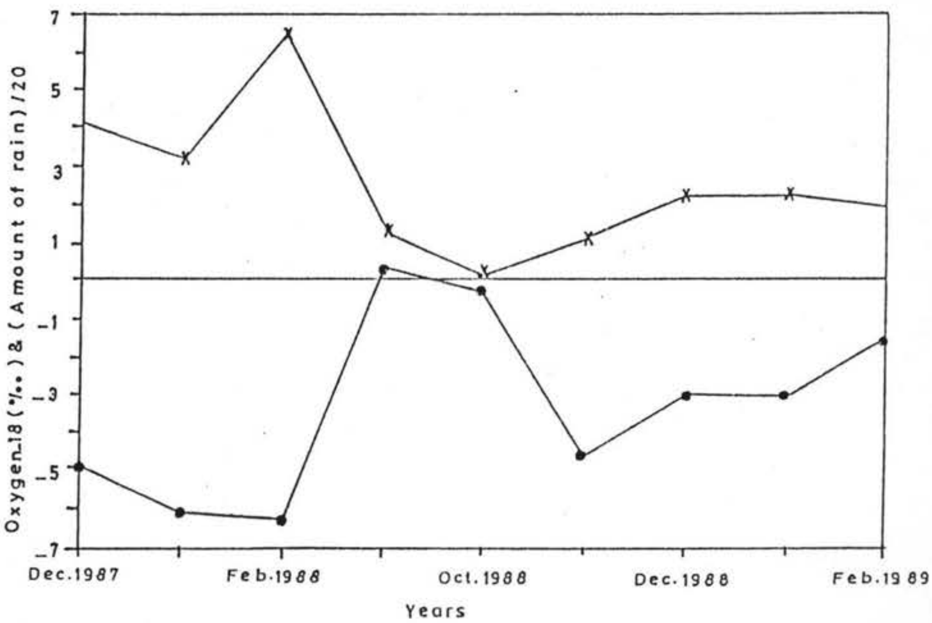
Worldwide there is a tendency that at high altitudes the δO^{18} values in precipitation water are depleted more than those at low altitudes; which is of practical significance for hydrological applications.

Figure (168), shows the changes in the isotope composition of rain from the Jordan Rift valley to the east along the movement of air mass, for the three rainfall station of Deir Alla, Ras Munif and Azraq. A continuous depletion in heavy isotopes of air masses during their ascent and passage over mountains is observed (from Deir Alla to Ras Munif). After that the composition, during its movement toward the east (lower altitude) becomes more enriched in heavy isotopes. The value of deuterium excess (d-parameter) in both lower altitude stations; Deir Alla and Azraq is lower than that of the mountain station of Ras Munif.

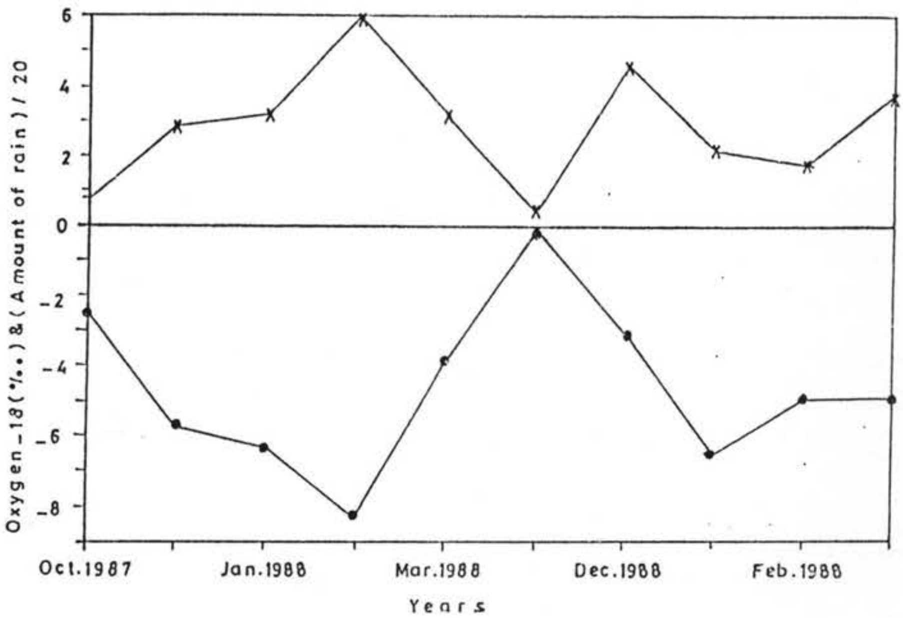
The obtained values of the isotope analyses indicate that the variation in the mean annual stable isotope composition is large especially in Deir Alla and Azraq stations. Furthermore, the small amount of rainfall is generally subjected to significant evaporation before reaching the earth surface.



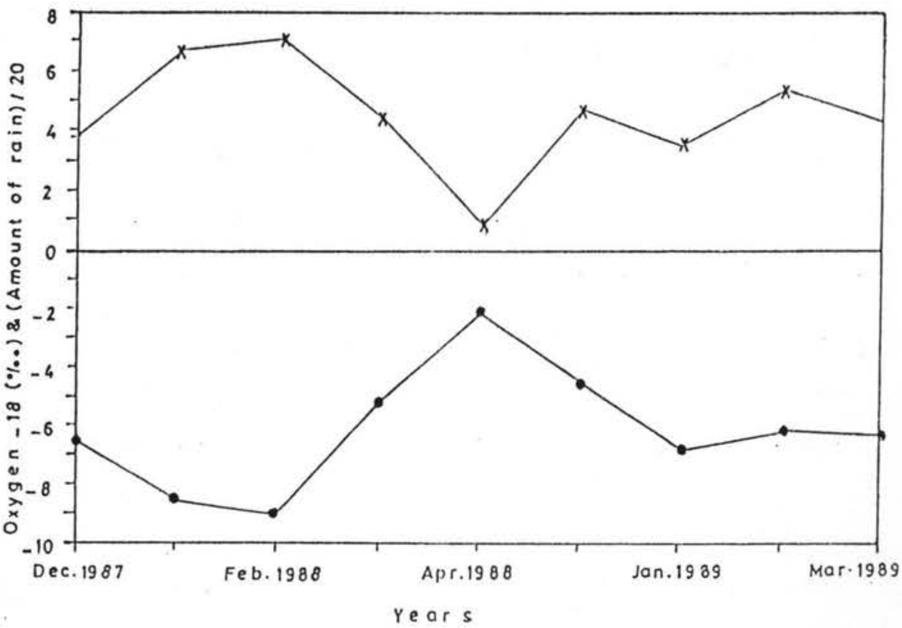
Figure(167A): Amount Effect in Ras Munif Station



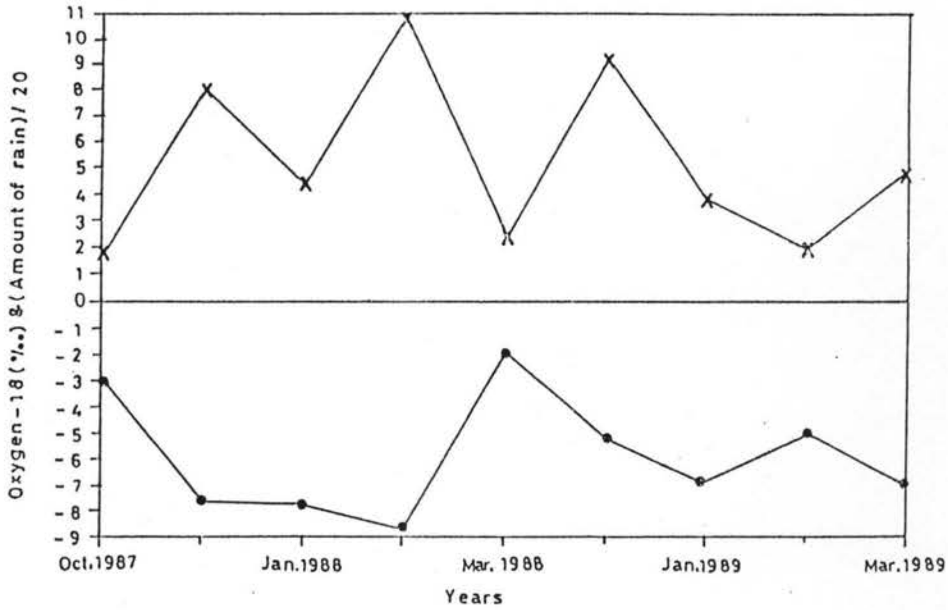
Figure(167B): Amount Effect in Dier Alla Station



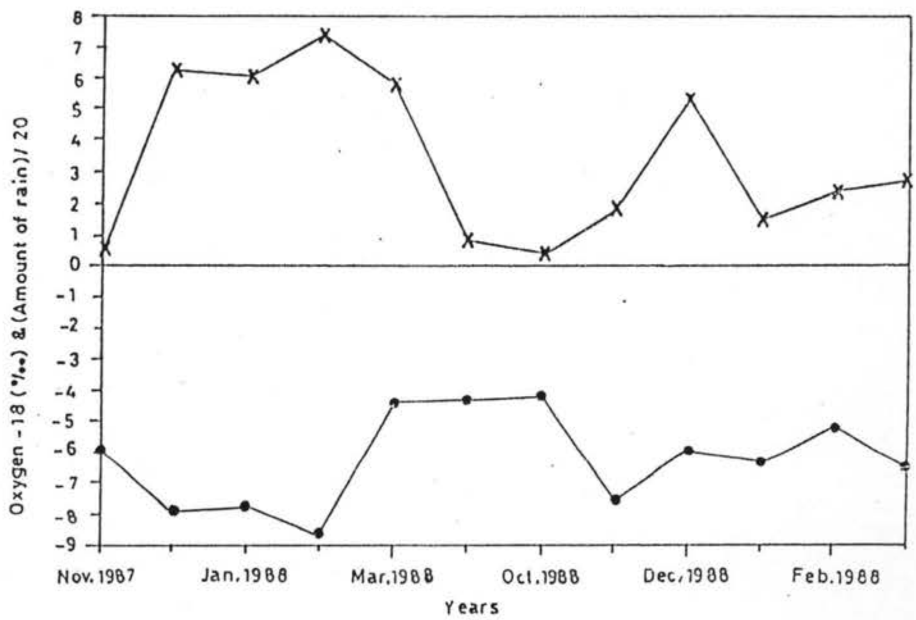
Figure(167C): Amount Effect in Wala Station



Figure(167D): Amount Effect in Rabba Station



Figure(167E): Amount Effect in Amman Station



Figure(167F): Amount Effect in Irbid Station

Tritium Concentration

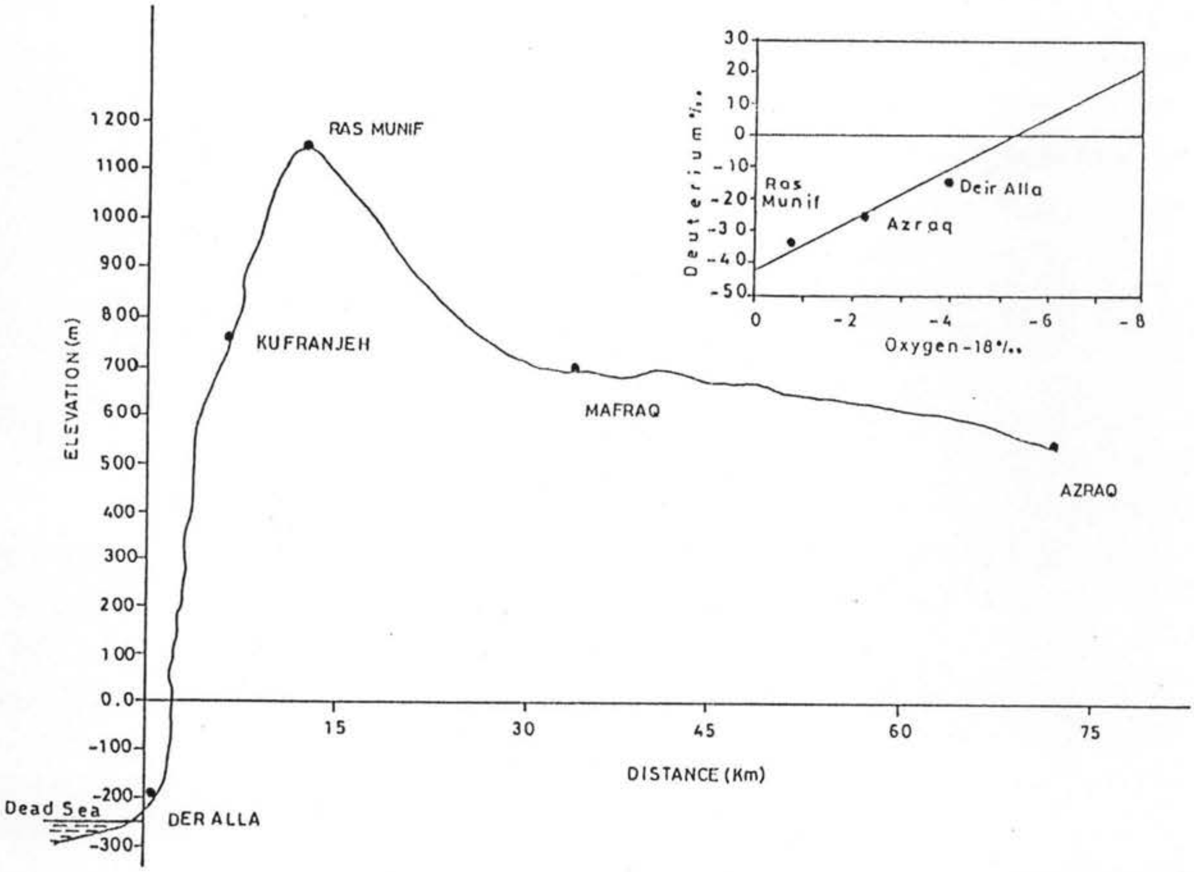
The available data on tritium concentration in precipitation water in Jordan from the two periods of (1965-1969 and 1987-1989) indicate a decreasing trend of tritium levels with time (figure 169). Figure (170) shows the time variation of tritium concentration during the last two years.

The variation of tritium levels in Rabba station is higher than those of other stations. The tritium levels in the other stations are also more homogeneous. This behavior could be explained by the effects imposed by the nuclear reactor installed at Dimone in Israel over which the air masses coming to Rabba area generally pass.

Correlation between δO^{18} and TDS, Ca^{2+}, SO_4^{2-} and HCO_3^- :

Good correlations were found between the δO^{18} and TDS, Ca, Cl and HCO_3 in January and March, but practically no correlation with the same parameters was obtained in December or February. Weak correlation with sulphate in January and March was found but none in December and February, table (26).

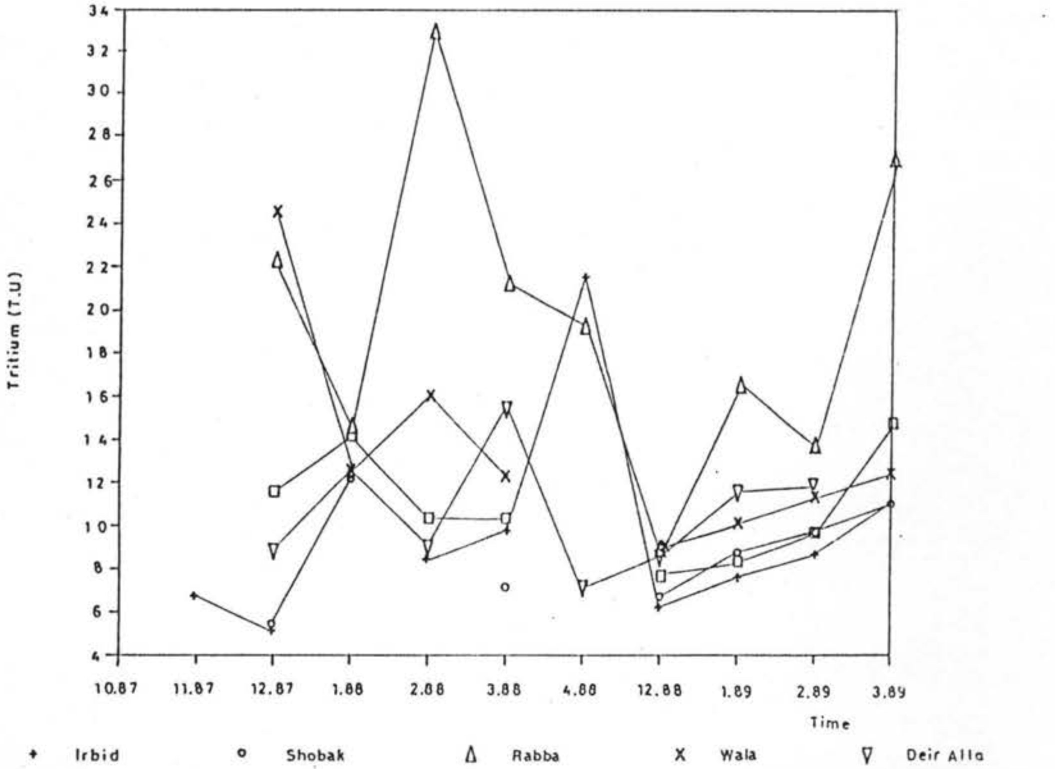
Figures 171 and 172 show the correlation of calcium, chloride and bicarbonate with O^{18} in January and March respectively. This phenomena could be a result of the different sources of air moisture and its path before entering the area. During January and March, polar air moisture gets isotopically enriched through passing over the Mediterranean sea. However, during December and February, the polar air moisture passes over the European continent, thus getting enriched with its urban and industrial gases and particles.



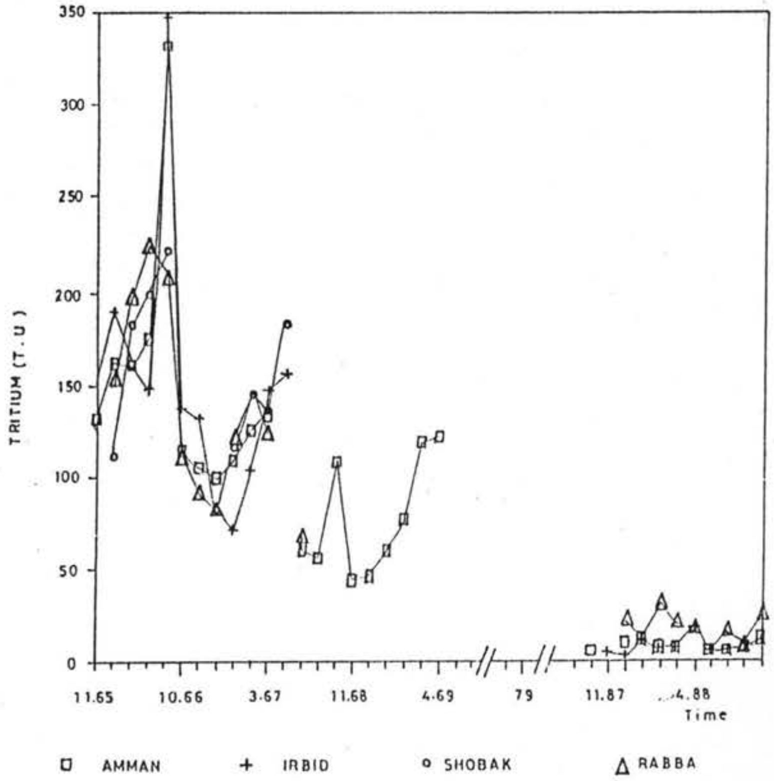
Figure(168): Evolution of Isotope Composition along an East-West Line (Deir Alla -Ras Munif - Azraq)

Table(26): Correlation Coefficient between O-18 and some Chemical Parameters.

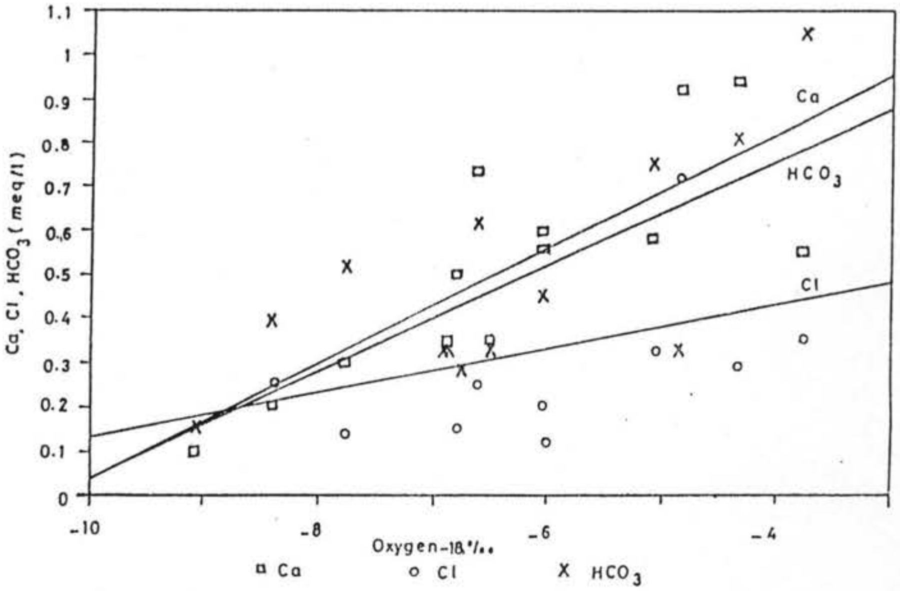
Months	TDS	Ca	Mg	Cl	SO4	HCO3
	PPM	MEQ/1	MEQ/1	MEQ/1	MEQ/1	MEQ/1
January	0.64	0.60	0.11	0.60	0.17	0.55
February	0.01	0.21	0.27	0.13	0.03	0.10
March	0.56	0.44	0.00	0.53	0.23	0.52
December	0.03	0.01	0.25	0.03	0.06	0.01



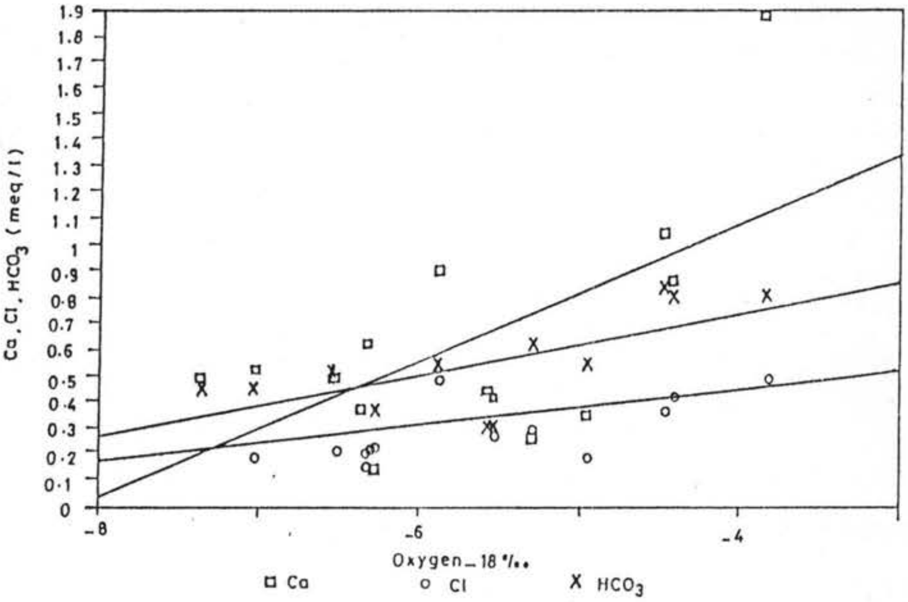
Figure(169): Tritium Concentration in Precipitation from 1965 - 1989



Figure(170): Tritium Concentration in Six Rainfall Stations



Figure(171): Precipitation in January



Figure(172): Precipitation in March

Conclusions

1. Throughout Jordan the major precipitation amounts result from depressions passing over the Mediterranean Sea. Minor contributions pass over the Red Sea at the desert - semi desert areas lying to the south and east of Jordan; the Arabian Desert.

2. Depressions passing over the Red Sea and the Arabian Desert contain higher amounts of dissolved and suspended matter. As these depressions extend over Jordan their dissolved and suspended loads decrease gradually from south/ Aqaba to morth/ Irbid and from east/ Azraq to west/ Amman.

3. The suspended materials in precipitation water are mainly found to be composed of calcite, quartz, clays and traces of gypsum and phosphates. The resulting dissolved solids in water increase the concentrations of all measured chemical parameters especially lithium and sulfate.

4. Western depressions passing over the Mediterranean have in general lower concentrations of dissolved and suspended constitents than those of the southern and eastern ones.

5. The western depression start normally with high concentrations of suspended and dissolved constitents which decrease as ppt continues; outraining effects.

As these depressions extend over Jordan to the south and east, their contents of dissolved and suspended solids generally increase due to the presence of a concentration which is higher than those to the west and north.

6. Precipitation as a result of western depressions posses initially high pH-values of around 8, decreasing gradually to a value of 5.6 after a continuous rain event of some 50 mm. Precipitation resulting from easterly and southerly depressions start with higher pH values, about 8.5, and decrease gradually to a minimum of 7.

7. Therefore, no acid rain as a result of industrialization or due to depressions passing over industrialised areas elsewhere, e.g. Europe, is expected to occur in Jordan, dust will compensate and buffer any acidifing agents.

8. The alkalinity of ppt water expressed as pH values increase in both southerly and easterly directions.

9. In average, the concentration of the dissolved solids increase from west to east and from north to south not only as a result of decreasing precipitation, but also because of the higher loads of dust particles present in the atmosphere.

10. Local conditions affect also the composition of precipitation water:

a. Rainfall in Deir Alla contains higher amount of dissolved solids, and especially higher concentrations of sulfates, phosphates, nitrates and bromide.

b. Rainfall in Khalidiya, Zerka and Ruseifeh show relatively higher concentrations of phosphates, nitrates, fluoride and sulfate as a result of phosphate mining, the emissions of the oil refinary and power stations of Hussein thermal station and the extensive agricnltnal aetivities.

c. Rainfall in Azraq contains the highest concentrations of dissolved solids due to the evaporation and vaporisation of Salt marshes and Salt deposits. Agricultural activities and Salt mining are the causes of higher concentrations of the different constituents.

d. Rainfall in Rabba-Shobak area show relatively higher concentration of chlorides and magnesium as a result of vaporisation of the Dead Sea aerosols.

11. In all the stations the mean deuterium excess (d-parameter) values are close to the east Mediterranean Meteoric Water Line with an average value of 22. There are no significant differences between the weighted mean and the unweighed mean values.

12. The stable isotopic data for waters, which are significantly subjected to evaporation, exhibit relatively small deuterium excess as compared to non-evaporated waters in the region.

13. The low slope of the regression line representing all stations indicates that there are other factors responsible for this phenomenon than the kinetic condensation process.

14. The enrichment of both oxygen-18 and low deuterium excess, for April and May samples may be explained by the movement of air moisture from the Atlantic Ocean via north Africa before entering the area.

15. Measurements of isotopes from the Jordan Valley to the east, e.g. Deir-Alla and Azraq and from the north to south e.g. Wala

and Shobak, indicate that the isotopic composition of precipitation became more depleted with increasing elevation.

16. The four snow samples from Amman station show a high depletion in stable isotope and a high value of deuterium excess of more than 30 o/oo. January precipitation recorded also high values of deuterium excess in the different stations.

17. Six stations; Ras Munif, Irbid, Deir Alla, Amman, Wala and Rabba show noticeable correlation coefficients with the amount of precipitation, i.e. the isotopic values are more depleted with intense rain , hence assuring the amount effect.

18. Different stations show different isotopic correlations with temperature, the highest correlation was found for Ras Munif, Rabba and Amman and the lowest for Deir Alla.

19. Generally, the tritium content of precipitation samples is, more or less, stable. The general rise in tritium content from winter months to spring months, which characterizes most northern hemisphere stations, can be recognized in Jordan.

The characteristic annual decrease in tritium concentration, since the stop of atom bumb, is also experienced in Jordan.

20. Rabba station shows a high content of tritium compared with the other stations in Jordan; which can be attributed to Dimone nuclear reactor emissions.

Ammendum

Trace Elements

The collected samples in the different stations were analysed for their content of trace elements by the use of atomic absorption techniques, where most of the samples had to be concentrated prior to the analyses.

In general, the samples contents of heavy metals were below the detection limit of the instrument. Only few samples showed higher contents of iron, zinc, manganese, cupper and lead. These samples were collected at the beginning of the rainy season or after a sandy storm crossed the country especially, the Khamasien winds. Tables 1 through 12 show the minimum and the maximum concentrations of these elements for all stations.

Iron showed the highest concentration due to the presence of iron oxides in the sandy and Khamasien winds, which was also reflected in the reddish color of precipitation after Khamasien winds or following an eastern or southern rainy fronts.

In Khalidiya, Zarka and Rusiefeh, some local rainfalls contained trace elements due to industrial pollutions resulting in more acidic rain. The oil refinery, the phosphate mines and other industries are responsible for the trace elements and lower pH. This slightly acidic rain prevailed only at the beginning of a rainy season, causing the iron, sulfur and nitrogen oxides to be dissoluted into the rain water.

Urbanization also had an effect on the precipitation water content of lead, which can be noticed from the concentration of

HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-UNI VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32066.0	32965.0	32449.932	291.734
QUANT mm	0.2	90.0	12.958	13.955
TEMP °C	0.0	21.0	8.626	4.358
pH-value	4.85	8.80	7.2099	0.8015
EC µS/cm	9.1	396.0	75.586	70.715
Na meq/l	0.000	2.194	0.18342	0.33191
K meq/l	0.001	0.142	0.02103	0.02460
Mg meq/l	0.000	0.711	0.08799	0.11017
Ca meq/l	0.073	2.444	0.46383	0.41741
Cl meq/l	0.020	1.892	0.25794	0.28918
NO3meq/l	0.001	0.384	0.05179	0.05675
SO4meq/l	0.010	0.901	0.17004	0.17694
HCO3meq/	0.024	1.721	0.27600	0.29948
TC meq/l	0.091	3.960	0.75626	0.70708
TA meq/l	0.091	3.960	0.75578	0.70704
I mg/l	0.000	0.110	0.01210	0.01652
Br mg/l	0.000	0.900	0.04883	0.11044
F mg/l	0.001	0.210	0.04655	0.04703
PO4 mg/l	0.000	0.521	0.12502	0.16346
TOC mg/l	8.10	8.10	8.1000	-0.0000
Li mg/l	0.000	0.070	0.01259	0.01705
TURBIDY	0.0	110.0	10.786	17.748
COLOR	0.0	90.0	15.203	24.042
TDS 104	0.010	0.450	0.10029	0.10907
TDS 180	0.000	0.400	0.08271	0.10314
Ag mg/l	0.00000	1.00000	1.994E-02	1.096D-01
TIME hr	7.15	17.00	10.1397	3.4830
Fe mg/l	0.00110	3.00000	2.330E-01	5.503D-01
Cu mg/l	0.00000	0.03950	2.136E-03	5.628D-03
Mn mg/l	0.00000	0.11690	5.170E-03	1.667D-02
Zn mg/l	0.00000	0.84800	5.119E-02	1.278D-01
Pb mg/l	0.00000	0.02070	1.002E-03	2.842D-03
Cr mg/l	0.00000	0.03590	1.178E-03	4.535D-03
Ni mg/l	0.00000	0.05570	2.595E-03	9.624D-03
Sr mg/l	0.00120	0.21700	4.032E-02	5.685D-02

Table(1): Descriptive Statistics for the University of Jordan Station

HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-RUSF VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32055.0	32582.0	32279.045	209.965
QUANT mm	0.1	52.6	8.141	11.338
TEMP °C	11.2	16.2	14.485	1.949
pH VALUE	6.87	8.42	7.5814	0.3926
EC µS/cm	66.0	252.0	136.418	61.448
Na meq/l	0.015	0.881	0.27162	0.22707
K meq/l	0.004	0.121	0.03031	0.03069
Mg meq/l	0.000	0.783	0.17365	0.18777
Ca meq/l	0.220	1.668	0.88860	0.41521
Cl meq/l	0.147	0.477	0.27495	0.09503
NO3 meq/	0.009	0.129	0.05721	0.03277
SO4 meq/	0.043	1.239	0.44310	0.34568
HCO3 meq	0.214	0.976	0.52727	0.22070
TC meq/l	0.660	2.520	1.36418	0.61448
TA meq/l	0.660	2.520	1.36418	0.61448
I mg/l	0.000	0.023	0.00790	0.00631
Br mg/l	0.000	0.288	0.11283	0.10565
F mg/l	0.010	0.178	0.06038	0.05240
PO4 mg/l	0.177	4.198	1.79943	1.52755
TOC mg/l				
Li mg/l	0.000	0.020	0.00563	0.00961
TURBIDY	0.0	15.0	5.429	6.106
COLOR	2.0	20.0	6.000	6.351
TDS 104	0.010	0.170	0.06800	0.06797
TDS 180	0.000	0.050	0.01800	0.02490
Ag mg/l	0.00000	0.00560	5.257E-04	1.250D-03
TIME hr				
Fe mg/l	0.00000	3.07000	5.637E-01	1.003D+00
Cu mg/l	0.00000	0.00880	2.484E-03	3.149D-03
Mn mg/l	0.00000	0.08400	1.472E-02	2.349D-02
Zn mg/l	0.00000	0.63200	1.303E-01	1.759D-01
Pb mg/l	0.00000	0.00360	6.000E-04	1.126D-03
Cr mg/l	0.00000	0.00650	7.000E-04	1.906D-03
Ni mg/l	0.00000	0.00850	1.033E-03	2.605D-03
Sr mg/l	0.02000	0.13000	6.040E-02	4.604D-02

Table(2): Descriptive Statistics for Rusiefeh Station

STASY V7.0:/12 (C) PIC GMBH WRSC UNIV.JORDAN 10.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-KHLD VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32122.0	32964.0	32518.266	316.003
QUANT mm	0.2	39.1	6.835	7.888
TEMP °C	0.0	16.2	13.700	5.069
pH VALUE	6.28	8.74	7.6020	0.5106
EC µS/cm	40.0	570.0	165.092	109.182
Na meq/l	0.011	1.054	0.23290	0.20548
K meq/l	0.002	0.926	0.08035	0.14005
Mg meq/l	0.000	1.065	0.17478	0.20585
Ca meq/l	0.270	3.329	1.16464	0.77502
Cl meq/l	0.074	1.594	0.33432	0.26072
NO3 meq/	0.018	1.619	0.11364	0.24001
SO4 meq/	0.052	1.645	0.37418	0.35817
HCO3 meq	0.116	4.810	0.82879	0.80323
TC meq/l	0.400	5.700	1.65267	1.09174
TA meq/l	0.400	5.700	1.65092	1.09182
I mg/l	0.000	0.025	0.00993	0.00838
Br mg/l	0.000	1.550	0.22617	0.33818
F mg/l	0.001	0.087	0.03770	0.02773
PO4 mg/l	0.000	3.810	0.71033	1.05948
TOC mg/l				
Li mg/l	0.000	0.064	0.02134	0.01825
TURBIDY	0.0	30.0	12.912	11.127
COLOR	1.0	67.5	20.979	21.559
TDS 104°	0.020	0.180	0.09813	0.06221
TDS 180°	0.010	0.190	0.06824	0.05318
Ag mg/l	0.00000	0.08500	3.468E-03	1.571D-02
TIME hr	8.00	17.00	12.5000	6.3640
Fe mg/l	0.00000	21.76000	1.695E+00	4.977D+00
Cu mg/l	0.00000	0.02300	3.963E-03	6.381D-03
Mn mg/l	0.00000	0.27700	2.911E-02	6.377D-02
Zn mg/l	0.00000	0.63000	7.387E-02	1.509D-01
Pb mg/l	0.00000	0.00200	3.742E-04	6.370D-04
Cr mg/l	0.00000	0.02200	1.528E-03	5.053D-03
Ni mg/l	0.00000	0.05830	8.558E-03	1.818D-02
Sr mg/l	0.00268	0.08700	4.838E-02	3.298D-02

Table(3): Descriptive Statistics for Khalidiya Station

HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-AZRQ VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32129.0	32490.0	32299.188	144.623
QUANT mm	0.1	11.0	2.609	3.028
TEMP °C.	9.0	32.6	16.908	6.479
pH VALUE	6.34	7.67	7.1392	0.3422
EC µS/cm	19.0	642.0	272.740	173.381
Na meq/l	0.009	2.381	0.60578	0.60539
K meq/l	0.001	0.149	0.05798	0.04675
Mg meq/l	0.000	1.447	0.32184	0.41031
Ca meq/l	0.175	4.573	1.74182	1.16373
Cl meq/l	0.061	1.953	0.66841	0.55458
NO3 meq/	0.025	0.560	0.11351	0.11384
SO4 meq/	0.000	2.617	0.70191	0.68831
HCO3 meq	0.101	2.733	1.24357	0.86042
TC meq/l	0.190	6.420	2.72740	1.73381
TA meq/l	0.190	6.420	2.72740	1.73381
I mg/l	0.000	0.445	0.07433	0.13930
Br mg/l	0.000	0.830	0.17038	0.23331
F mg/l	0.008	0.252	0.09714	0.07702
PO4 mg/l	0.000	1.141	0.50385	0.42830
TOC mg/l				
Li mg/l	0.000	0.120	0.04050	0.03938
TURBIDY	5.0	100.0	42.091	33.599
COLOR	1.0	80.0	23.214	25.329
TDS 104°	0.180	0.440	0.29600	0.13221
TDS 180°	0.160	0.430	0.27200	0.13989
Ag mg/l	0.00000	0.00270	1.217E-03	1.161D-03
TIME hr				
Fe mg/l	0.02500	1.93000	6.344E-01	7.666D-01
Cu mg/l	0.00000	0.01060	4.406E-03	4.602D-03
Mn mg/l	0.00000	0.05670	1.940E-02	2.260D-02
Zn mg/l	0.00000	0.10500	4.808E-02	4.650D-02
Pb mg/l	0.00000	0.00486	2.320E-03	1.926D-03
Cr mg/l	0.00000	0.00347	8.140E-04	1.507D-03
Ni mg/l	0.00000	0.04980	1.358E-02	2.171D-02
Sr mg/l				

Table(4): Descriptive Statistics for Azraq Station

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32123.0	32917.0	32514.809	327.689
QUANT mm	0.1	39.0	6.879	7.601
TEMP °C	5.0	18.2	9.257	2.903
pH VALUE	5.80	8.80	7.5863	0.5978
EC µS/cm	20.0	415.0	114.350	68.025
Na meq/l	0.008	1.330	0.23192	0.28327
K meq/l	0.003	0.166	0.04788	0.04110
Mg meq/l	0.000	0.828	0.17703	0.17299
Ca meq/l	0.000	2.394	0.68669	0.41479
Cl meq/l	0.082	1.513	0.39788	0.26715
NO3 meq/	0.001	0.496	0.05640	0.07675
SO4 meq/	0.046	0.779	0.22112	0.17365
HCO3 meq	0.049	1.362	0.46812	0.33304
TC meq/l	0.201	4.150	1.14351	0.68023
Ta meq/l	0.200	4.150	1.14350	0.68025
I mg/l	0.000	0.261	0.02184	0.04627
Br mg/l	0.000	0.380	0.05754	0.08226
F mg/l	0.008	0.153	0.05017	0.04410
PO4 mg/l	0.011	1.967	0.46454	0.47741
TOC mg/l				
Li mg/l	0.000	0.112	0.03176	0.03258
TURBIDY	0.0	80.0	13.022	17.513
COLOR	0.4	100.0	24.860	26.993
TDS 104°	0.060	0.150	0.10200	0.02700
TDS 180°	0.050	0.130	0.08750	0.02372
Ag mg/l	0.00000	0.01900	1.870E-03	3.967D-03
TIME hr				
Fe mg/l	0.00710	2.66100	2.642E-01	6.727D-01
Cu mg/l	0.00000	0.01100	1.669E-03	3.338D-03
Mn mg/l	0.00000	0.23000	1.883E-02	5.862D-02
Zn mg/l	0.00000	0.12100	3.799E-02	4.129D-02
Pb mg/l	0.00000	0.00440	1.303E-03	1.652D-03
Cr mg/l	0.00000	0.00750	7.133E-04	1.965D-03
Ni mg/l	0.00000	0.00000	0.000E+00	0.000D+00
Sr mg/l	0.06100	0.07900	7.000E-02	1.273D-02

Table(5): Descriptive Statistics for Rabba Station

STASY V7.02/12 (C) PIC GMBH — WRSC UNIV.JORDAN 13.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN — DATEI A:NEW-SHBK VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32141.0	32873.0	32362.500	300.012
pH VALUE	7.05	7.70	7.3117	0.3013
EC µS/cm	48.0	151.0	96.500	36.462
Na meq/l	0.011	0.403	0.16586	0.13617
K meq/l	0.000	0.027	0.00910	0.01023
Mg meq/l	0.058	0.372	0.16805	0.11467
Ca meq/l	0.386	0.900	0.62195	0.18831
Cl meq/l	0.106	0.504	0.27917	0.16321
NO3 meq/	0.020	0.076	0.05100	0.02362
So4 meq/	0.050	0.384	0.20741	0.13252
HCO3 meq	0.154	0.751	0.42747	0.23906
TC meq/l	0.480	1.510	0.96500	0.36462
TA meq/l	0.480	1.510	0.96500	0.36462
I mg/l	0.001	0.018	0.00700	0.00765
Br mg/l	0.005	1.300	0.34060	0.58350
F mg/l	0.032	0.105	0.07867	0.04053
PO4 mg/l	0.000	0.734	0.24633	0.42234
Li mg/l	0.010	0.030	0.02133	0.01026
TURBIDY	0.0	28.0	14.000	19.799
COLOR	0.0	8.0	3.000	4.359
Fe mg/l	0.00000	0.03230	1.077E-02	1.865D-02
Cu mg/l	0.00000	0.00580	1.933E-03	3.349D-03
Mn mg/l	0.00000	0.00160	5.333E-04	9.238D-04
Zn mg/l	0.00000	0.00167	5.567E-04	9.642D-04
Pb mg/l	0.00110	0.00530	2.667E-03	2.294D-03
Cr mg/l	0.00000	0.00000	0.000E+00	0.000D+00
Ni mg/l	0.00000	0.00000	0.000E+00	0.000D+00

Table(6): Descriptive Statistics for Shobak Station

STASY V7.02/12 (C) PIC GMBH — WRSC UNIV.JORDAN 10.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN — DATEI A:NEW-SALT VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32071.0	32964.0	32329.770	311.500
QUANT mm	0.2	57.0	10.210	13.857
TEMP °C	6.2	16.7	10.813	3.932
pH VALUE	6.39	8.74	7.6074	0.5676
EC µS/cm	18.0	372.0	98.679	71.503
Na meq/l	0.000	2.245	0.31673	0.45242
K meq/l	0.004	0.322	0.04641	0.06208
Mg meq/l	0.000	0.456	0.15719	0.11318
Ca meq/l	0.101	1.033	0.46647	0.25779
Cl meq/l	0.045	2.205	0.42247	0.43436
NO3 meq/	0.004	0.214	0.05718	0.05128
SO4 meq/	0.031	0.900	0.18823	0.19396
HCO3 meq	0.095	0.719	0.31892	0.15519
TC meq/l	0.180	3.720	0.98680	0.71503
TA meq/l	0.180	3.720	0.98679	0.71503
I mg/l	0.000	0.060	0.00637	0.01122
Br mg/l	0.000	0.390	0.06623	0.09149
F mg/l	0.002	0.292	0.03922	0.07140
PO4 mg/l	0.000	2.600	0.80273	0.65894
TOC mg/l				
Li mg/l	0.000	0.060	0.01927	0.01913
TURBIDY	0.0	40.0	15.500	12.083
COLOR	0.0	54.0	14.938	22.133
TDS 104°	0.010	0.130	0.07000	0.04336
TDS 180°	0.000	0.080	0.05167	0.03371
Ag mg/l	0.00000	0.03300	2.175E-03	6.031D-03
TIME hr				
Fe mg/l	0.00000	7.01960	7.932E-01	1.684D+00
Cu mg/l	0.00000	0.30000	4.619E-02	8.288D-02
Mn mg/l	0.00000	0.07420	1.276E-02	1.891D-02
Zn mg/l	0.00000	0.69000	2.321E-01	2.053D-01
Pb mg/l	0.00000	0.01500	4.151E-03	4.495D-03
Cr mg/l	0.00000	0.01607	9.841E-04	3.891D-03
Ni mg/l	0.00000	0.28900	5.996E-02	8.936D-02
Sr mg/l				

Table(7): Descriptive Statistics for Salt Station

STASY V7.02/12 (C) PIC GMBH   WRSC UNIV.JORDAN 10.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN   DATEI A:NEW-IRBT VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32082.0	32550.0	32263.750	189.810
QUANT mm	0.8	31.8	9.431	8.734
TEMP °C	3.8	19.8	13.087	4.815
pH VALUE	6.55	8.07	7.2006	0.3737
EC µS/cm	31.0	365.0	95.162	93.167
Na meq/l	0.006	0.538	0.17571	0.16214
K meq/l	0.005	0.741	0.06047	0.18208
Mg meq/l	0.000	0.920	0.18726	0.21718
Ca meq/l	0.162	2.122	0.52815	0.58975
Cl meq/l	0.067	0.619	0.22882	0.14325
NO3 meq/	0.007	0.454	0.05595	0.10755
SO4 meq/	0.023	1.423	0.27290	0.43576
HCO3 meq	0.078	1.155	0.39388	0.33222
TC meq/l	0.310	3.650	0.95163	0.93167
TA meq/l	0.310	3.650	0.95162	0.93167
I mg/l	0.008	0.032	0.01888	0.00866
Br mg/l	0.001	0.040	0.02050	0.02758
F mg/l	0.009	0.092	0.04283	0.03686
PO4 mg/l	1.170	4.990	3.64500	1.74298
TOC mg/l				
Li mg/l	0.000	0.022	0.01680	0.00944
TURBIDY	0.0	6.0	2.333	2.338
COLOR	0.0	2.5	1.167	1.033
TDS 104°	0.090	0.100	0.09500	0.00707
TDS 180°	0.040	0.050	0.04500	0.00707
Ag mg/l	0.00000	0.03300	3.638E-03	9.150D-03
TIME hr				
Fe mg/l	0.00900	0.52900	2.690E-01	3.677D-01
Cu mg/l	0.00000	0.00500	2.500E-03	3.536D-03
Mn mg/l	0.00000	0.03900	1.950E-02	2.758D-02
Zn mg/l				
Pb mg/l	0.00120	0.00140	1.300E-03	1.414D-04
Cr mg/l	0.00000	0.00370	1.850E-03	2.616D-03
Ni mg/l	0.00000	0.00000	0.000E+00	0.000D+00

Table(8): Descriptive Statistics for Irbid Town Station

STASY V7.02/12 (C) PIC GMBH   WRSC UNIV.JORDAN 10.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN   DATEI A:NEW-IRBW VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32066.0	32523.0	32238.680	187.316
QUANT mm	0.3	34.0	7.354	8.662
TEMP °C	12.3	14.7	13.750	1.133
pH VALUE	6.72	7.66	7.2684	0.3105
EC µS/cm	23.0	436.0	192.244	116.349
Na meq/l	0.002	1.320	0.47806	0.42876
K meq/l	0.004	0.145	0.03107	0.03272
Mg meq/l	0.000	0.549	0.24883	0.16724
Ca meq/l	0.070	3.618	1.16446	0.78655
Cl meq/l	0.016	1.603	0.53973	0.40965
NO3 meq/	0.014	0.229	0.06776	0.05024
SO4 meq/	0.028	2.251	0.61734	0.54536
HCO3 meq	0.013	1.465	0.69761	0.43223
TC meq/l	0.230	4.360	1.92244	1.16349
TA meq/l	0.230	4.360	1.92244	1.16349
I mg/l	0.000	0.230	0.03838	0.07789
Br mg/l	0.000	0.880	0.15722	0.27500
F mg/l	0.000	0.065	0.01840	0.02693
PO4 mg/l	0.000	0.360	0.26100	0.11456
TOC mg/l				
Li mg/l	0.000	0.032	0.02511	0.01059
TURBIDY	0.0	6.0	4.333	1.871
COLOR	0.0	4.0	2.167	1.118
TDS 104°	0.000	0.040	0.02333	0.01323
TDS 180°	0.000	0.010	0.00111	0.00333
Ag mg/l	0.00000	0.00530	8.875E-04	1.334D-03
TIME hr				
Fe mg/l	0.00000	0.03710	1.860E-02	1.517D-02
Cu mg/l	0.00000	0.00160	4.000E-04	8.000D-04
Mn mg/l	0.00000	0.00091	3.600E-04	4.437D-04
Zn mg/l	0.00000	0.12790	4.235E-02	5.902D-02
Pb mg/l	0.00000	0.00350	8.750E-04	1.750D-03

Table(9): Descriptive Statistics for Irbid Weather Station

STASY V7.02/12 (C) PIC GMBH WRSC UNIV.JORDAN 13.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-FARM VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32125.0	32876.0	32411.953	253.348
QUANT mm	0.1	29.2	9.614	8.795
TEMP °C	11.2	30.1	18.448	4.981
pH VALUE	6.50	8.26	7.4919	0.4174
EC µS/cm	41.0	500.0	159.843	133.253
Na meq/l	0.022	1.278	0.37413	0.33775
K meq/l	0.000	0.140	0.03727	0.03840
Mg meq/l	0.000	1.825	0.30619	0.46053
Ca meq/l	0.286	2.543	0.88083	0.58823
Cl meq/l	0.095	1.554	0.47344	0.43084
NO3 meq/	0.021	0.125	0.06178	0.03001
SO4 meq/	0.081	1.008	0.35276	0.26168
HCO3meq/	0.189	2.599	0.71043	0.68535
TC meq/l	0.410	5.000	1.59845	1.33253
Ta meq/l	0.410	5.000	1.59843	1.33253
I mg/l	0.001	0.030	0.01436	0.00914
Br mg/l	0.000	2.520	0.31533	0.66471
F mg/l	0.005	0.394	0.09912	0.13164
PO4 mg/l	0.000	0.723	0.08483	0.21396
Li mg/l	0.013	0.260	0.06609	0.07533
TURBIDY	0.0	12.0	3.545	5.126
COLOR	0.0	15.0	5.167	6.021
TDS 104°	0.010	0.210	0.15200	0.08319
TDS 180°	0.000	0.200	0.09400	0.07232
Ag mg/l	0.00000	0.00616	1.022E-03	2.128D-03
Fe mg/l	0.00000	0.52900	1.625E-01	1.774D-01
Cu mg/l	0.00000	0.00213	7.114E-04	7.072D-04
Mn mg/l	0.00000	0.01500	5.504E-03	5.411D-03
Zn mg/l	0.00000	1.17000	2.622E-01	3.480D-01
Pb mg/l	0.00000	0.00840	8.329E-04	2.288D-03
Cr mg/l	0.00000	0.00280	7.807E-04	1.132D-03
Ni mg/l	0.00000	0.34000	6.207E-02	1.111D-01
Sr mg/l	0.01400	0.37000	1.491E-01	1.314D-01

Table(10): Descriptive Statistics for University Farm Station

STASY V7.02/12 (C) PIC GMBH WRSC UNIV.JORDAN 13.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-QAIA VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32066.0	32140.0	32088.000	29.198
QUANT mm	0.8	4.8	2.720	1.555
TEMP °C	15.4	20.2	18.025	2.488
pH VALUE	7.68	9.03	8.0540	0.5528
ECμS/cm	83.0	315.0	206.000	93.247
Na meq/l	0.037	0.900	0.45316	0.40338
K meq/l	0.019	0.147	0.08449	0.06000
Mg meq/l	0.000	0.885	0.22309	0.37466
Ca meq/l	0.443	2.028	1.29927	0.74243
Cl meq/l	0.160	0.791	0.50560	0.28657
NO3 meq/	0.036	0.621	0.30482	0.22931
SO4 meq/	0.062	1.778	0.79416	0.67062
HCO3 meq	0.245	0.808	0.45532	0.21956
TC meq/l	0.830	3.150	2.06000	0.93247
TA meq/l	0.830	3.150	2.06000	0.93247
I mg/l	0.020	0.038	0.02933	0.00902
Br mg/l	0.010	0.260	0.09333	0.14434
F mg/l	0.045	0.066	0.05550	0.01485
Ag mg/l	0.00000	0.00500	3.750E-03	2.500D-03

Table(11): Descriptive Statistics for Queen Alia Intr. Airport

STASY V7.02/12 (C) PIC GMBH WRSC UNIV.JORDAN 10.10.90

HYDROCHEMISTRY OF PPTION IN JORDAN DATEI A:NEW-MUWQ VOM 15.07.15

2.1 DESKRIPTIVE STATISTIK (KURZ)

VARIABLE	MINIMUM	MAXIMUM	MITTELWERT	STD.ABW.
DATE	32086.0	32963.0	32533.773	355.779
QUANT mm	0.4	23.0	6.050	8.089
TEMP °C	16.2	18.6	16.600	0.980
pH VALUE	4.00	8.15	7.4821	0.7372
EC μS/cm	30.0	373.0	165.077	101.292
Na meq/l	0.020	1.189	0.34424	0.28672
K meq/l	0.001	0.144	0.03727	0.03983
Mg meq/l	0.000	0.751	0.20356	0.22581
Ca meq/l	0.211	2.920	1.06569	0.65364
Cl meq/l	0.067	2.780	0.58456	0.56776
NO3 meq/	0.009	0.363	0.09401	0.07292
SO4 meq/	0.024	1.909	0.32569	0.37941
HCO3 meq	0.093	4.934	0.92866	1.03810
TC meq/l	0.300	3.730	1.65076	1.01292
TA meq/l	0.300	3.730	1.65077	1.01292
I mg/l	0.000	0.026	0.01261	0.00935
Br mg/l	0.001	0.565	0.12942	0.17741
F mg/l	0.012	0.353	0.08110	0.10338
PO4 mg/l	0.155	0.510	0.32500	0.12309
TOC mg/l				
Li mg/l	0.000	0.130	0.03426	0.03048
TURBIDY	6.0	110.0	41.133	30.071
COLOR	3.0	70.0	20.633	19.720
TDS 104°	0.010	0.480	0.14500	0.11713
TDS 180°	0.000	0.455	0.12594	0.11503
Ag mg/l	0.00000	0.34800	2.957E-02	8.137D-02
TIME hr				
Fe mg/l	0.01800	2.58000	1.227E+00	1.066D+00
Cu mg/l	0.00110	0.01380	6.150E-03	4.653D-03
Mn mg/l	0.00000	0.06300	2.395E-02	2.545D-02
Zn mg/l	0.01550	0.79200	2.802E-01	3.775D-01
Pb mg/l	0.00000	0.00750	2.472E-03	2.921D-03
Cr mg/l	0.00000	0.00300	1.000E-03	1.549D-03
Ni mg/l	0.00000	0.04350	1.000E-02	1.769D-02
Sr mg/l				

Table(12): Descriptive Statistics for Muwaqqar Station lead detected in the capital Amman, in Irbid which is the second biggest city in Jordan and in Zarka near the oil refinery.

Silver was detected occasionally in few samples collected during the study period and it is believed to be due to the cloud seeding experiments conducted by the department of meteorology.

Product moment correlations were made to work out the relationships between the concentrations of trace elements and other chemical and physical parameters. Poor correlations with all other elements were found. This proves the fact that the presence of trace elements is only due to local conditions prevailing in specific areas or due to the type and direction of the rainy fronts affecting Jordan.

Since this is the case , small scale studies are recommended both on air and precipitation quality. Each town or city should be monitored by different station distributed in its various parts. Hence, new rainfall collecting stations were installed this year in the center of Amman to study the effects of urbanization and transportation on precipitation water quality. Another station was also installed in the campus of the Bacheloriate school to study the effects of the cement factory. In Zarka a third station was installed to see the effects of the oil refinery and the nearby Al-Hussien Thermal Station on the precipitation water quality. The stations installed outside the urban or industries areas, will still be operated as control stations.

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