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Study of Some Environmental Parameters at Rajshahi City

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STUDY OF SOME ENVIRONMENTAL PARAMETERS AT RAJSHAHI CITY

M. Phil Thesis

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Submitted by
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Dedicated to
My
Parents

DECLARATION

I hereby certify that the work which is being presented in the thesis entitled **"STUDY OF SOME ENVIRONMENTAL PARAMETERS AT RAJSHAHI CITY"** in fulfillment of the requirement for the award of the Degree of Master of Philosophy in Physics subtended to University of Rajshahi is an authentic record of my own work carried out during the period from January 1995 to September 1999 under the supervision of Prof. M. Mozammel Haque, Rajshahi University, Rajshahi and Mr. Rokon Uddin, Director, Nuclear Medicine Centre, Khulna. The matter embodied in this thesis has not been submitted by me for the award of any other degree.

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Candidate's Signature

This is to certify that the above statement made by the candidate is correct to the best our knowledge.

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ABSTRACT

Environmental parameters such as humidity, rainfall, temperature, bright sunshine hour, wind speed, dew temperature and soil temperature of Rajshahi City were studied for the period 1995 to 1999. This was performed in order to interpret the climatic pattern of this City .

Also trace elements including heavy metals in different winter vegetables grown around Rajshahi City were determined using PIXE technique.

Results of some biologically important elements are discussed in detail.

CONTENTS

Chapter -1

General Introduction

1.1 ENVIRONMENT

Nature is a standard surroundings for the living bodies in this universe. Man is the integral part of it where he along with others are living. So, man has to try heart and soul to balance the environment in all respects. Since man takes something from nature but he returns almost nothing, therefore, there creates a balanceless situations in the environment that causes harmful effects on others.

The sum total of all the physical and biological components and processes which make up the surroundings of man is generally called the environment. It includes –(i) biophysical components of the natural resources such as land, water and air including all layers of the atmosphere, fisheries, wetlands and wild life and the physical and biological factors and processes which support these resources, and

(ii) Social components of the human communities including economic, administrative, cultural, historical, archaeological, land and associated usage, structures, sites, human health, nutrition and safety. By environment we mean all the external situation required to maintain bio-cycle and its fulfillment. So, environment is a system wherein living world, nonliving world and artificially made surroundings and hence socio-situation are included. There must exist deep inter-correlation among these elements of environment, interfering each other. Man always lives in such a situation where he has to perform some duties from personal and social initiation as individual and surroundings can never be separated from each other.

The main components of environment and its co-relation constantly exert influence on our livelihood and characteristics:

Man:

Population and its quantitative and qualitative factors, institutions and technologies, humanly behaviour, demand, supply, enjoyment, business etc. constantly exert burden on the wealth and environment of this universe.

Trees:

Different varieties of trees of seasonal based and those of short and long duration influence nature and environment from both quantitative and qualitative angles.

Living creatures:

Animals of different species play significant role in the daily activities of human life. Some are used as food, some help in agriculture and also some are involved in business. In this way, living creatures help us to maintain our livelihood.

Non-living bodies:

Non-living bodies such as air, sunlight, heat, light, energy, rain, water, land etc. exert also some load on the environment from quantitative and qualitative concept.

The environment affects man through (i) biophysical limitations, (ii) behavioural controls and (iii) resource availbility. Weather and climate affect human well-being and health. The study of reactions of human body to changes in the atmospheric environment is known as *'human biometeorology'* which lays emphasis on to 'establish how much of the overall biological variability is the result of changes in weather, climate and season [R-1]

Biologically, human body can function properly only in certain suites of environmental conditions in terms of oxygen, heat, light, humidity and precipitation, wind, lightning, fog, clouds, atmospheric electricity and space. Even the survival of human body depends on the above factors. Lack of required amount of oxygen at higher altitudes makes human survival impossible. Excessive heat and humidity retard body and mental growth whereas very high or very low temperature on the one hand adversely affects human body and on the other hand makes food a scarce commodity to support human life. *Micro-climate* affects leisure, recreation, comfort etc. Certain non-infectious diseases and medical disorders have been correlated with environmental factors such as geochemistry of rocks, soils and water. Concentration of a few trace minerals in the rocks, soils and water in the U.P. Himalayas causes stomach disorders through diarrhea, dysentery etc. M.Cole[R-2] has shown correlation between certain forms of cancer and cardio-vascular troubles and geochemical properties of soils and water whereas B.E Davies and R.J.F. H Pincent's [R-3] study of minerals and morbidity has revealed relationships between stomach cancer and hardening of tissues and arteries of human body (sclerosis) and certain trace minerals in the soils and water. Certain diseases and illnesses have been related to atmospheric conditions. E.H. derrick (1965, 1966, 1969) [R-4, 5, 6] has related seasonal, annual and short-term variations in asthma in Brisbane (Australia) to variations in weather conditions. He has related weeks with high incidence of asthma with decrease in mean and minimum temperature, due point, relative humidity and rainfall but increase in sunshine hours whereas low incidence of asthma has been found in those weeks which are characterised by higher due points and relative humidity, more rainy days, low temperature ranges and fewer hours of sunshine.

Man is an important part of the environment and simultaneously he is also an important factor of the environment. Thus man plays important roles in the natural environmental system in different capacities such as 'biological or physical man', 'Social man', 'economic man' and 'technological man'. All the natural functions of human beings such as birth, growth, health and deaths are affected and determined by the natural environment in the same manner as the cases of other organisms but man being most developed and advanced animal, both physically and mentally and hence technologically, is capable of making substantial changes in natural environment so as to make it suitable for his own living. The role of most primitive biological or 'physical man' in the functions of natural environmental system was fundamentally that of user of environmental resources and thus he played the role of a factor of the environment but as the skill and technology of man developed with cultural development his roles towards natural environment also changed progressively such as from user through modifier and changer to destroyer of the environment.

So it is the technology of man which has drastically changed the man-environment relationship from prehistoric period to the present most advanced industrial period. In fact, 'the industrial and scientific revolutions have led to rapid changes in our environment, but all technology, from the most primitive to the most advance, causes some changes in the environment' [R-7].

The dawn of industrial revolution in late nineteenth century(say precisely since 1860 A.D.) with the emergence of science and development of more efficient and sophisticated technology initiated the hostile relationship between man and his natural environment. Extreme concept of the western world, advanced technologies and scientific techniques of the modern 'technological man' led to reckless and indiscriminate rapacious exploitation of natural resources for industrial expansion and urban growth which have altogether created most of the present day environmental and ecological problems of global dimension.

The impacts of modern technological man on natural environment are varied and highly complex as the transformation or modification of one natural condition and process leads to a series of changes in the biotic and abiotic components of biosperic ecosystems.

The indirect impacts of man on the environment are not premeditated and planned and these arise from those human activities, which are directed to accelerate the pace of economic growth, especially industrial development. Though such economic activities may be economically important but the after-effects are certainly socially undesirable. The indirect impacts of human economic activities on the environment are not immediately noticeable because the effects of economic activities bring in slow rate of changes of moderate nature in a few components of the ecosystems and these changes take long time to cross the sensitivity of the system. More over the indirect impacts are experienced after long time when they become cumulative. Sometimes, such effects are not reversible and therefore it becomes very difficult to identify and evaluate them. These effects may change the overall natural system and the chain effects some times become sucidal for human being. Majority of the indirect impacts of human activities on the environment are related to pollution and environmental degradation.

Urbanisation, industrial expansion and land use changes very often change weather and climate though in long-term perspective. Economic activities of man are capable of affecting the heat balance of the earth and its atmosphere which in turn transforms weather and climate at regional and global scales. Infact man changes the atmospheric conditions through (i) changes in the natural gaseous composition of the atmosphere mainly in the lower part, (ii) changes in the water vapour content of the troposphere and the stratosphere through direct (cloud seeding) and indirect means (deforestation), (iii) changes and alteration of land surfaces (deforestation, mining, urbanisation etc.), (iv) introduction of aerosol in the lower atmosphere, (v) release of additional heat in the atmosphere (from urban and industrial sources) etc.

To most of the people environmental degradation and pollution are synonym as both are concerned with the lowering of the quality of the environment. But a distinction between these two aspects of the lowering and deterioration of the quality of the environment may be drawn on the basis of causative factors and scale of deterioration of environmental quality in terms of magnitude/intensity and covered area. Environment pollution means lowering of the quality of environment at local scale causes exclusively by human activities whereas environment degradation means lowering of environment quality at local, regional and global scales by both NATURAL PROCESSES and HUMAN ACTIVITIES. For example, volcanic eruptions, earthquakes, submergence and emergence, faulting, atmospheric storms like cyclones (typhoons), forest fires, atmospheric lightning, hailstorms, excessive snowfalls, geological erosion. landslides and avalanches etc. are the natural factors which cause destabilization of ecosystem and thus cause environmental degradation.

The environmental crisis caused due to environmental and ecological changes is the result of developmental processes of the economic and technological man of the present century. The environmental degradation and environmental crisis may be ascribed to (i) the exponential growth in human populations, (ii) accelerated pace of scientific and technological development, (iii) ambitious developmental projects aimed at fast economic development (iv) fastly expanding industries, sprawlling urban growth and agricultural development, (v) philosophical and religious outlook of the society, (vi) cruel behaviour of man with the natural environment, (vii) ignorance and lack of environmental perception and lack of public awareness towards environment problems, (viii) poverty, (ix) affluence and richness, (x) unscientific and illogical exploitation and utilization of natural resources,etc.

Environmental degradation is much bigger and comprehensive term which includes lowering and deterioration of environmental quality caused by both natural factors and anthropogenic factors from local level through regional level to global level. The events caused by either natural processes or anthropogenic processes, which bring immediate changes in the natural environment and inflict colossal damage and loss to the environmental quality and living organisms are called EXTREME EVENTS or HAZARDS which are further divided into two broad categories viz. (i) NATURAL HAZARDS (like tropical cyclones, volcanic eruptions, earthquakes, floods, droughts,etc.) and (ii) ANTHROPOGENIC or MAN-MADE HAZARDS) (like nuclear holocaust, chemical war, etc.) The deterioration of environmental quality beyond a critical limit caused by human activities is called POLLUTION.The environmental degradation/deterioration may be classified as given below-

Environmental Degradation: divided into two categories on the basis of factors responsible for the lowering of environmental quality and the level and magnitude of lowering/deterioration of environmental quality.

1. EXTREME EVENTS AND HAZARDS
2. POLLUTION

1. EXTREME EVENTS AND HAZARDS

(Divided into 3 sub-categories on the basis of causative factors)

(i) Natural Hazards

(Caused by natural factors)

Natural hazards are again divided into 3 subtypes.

(A) Terrestrial Natural Hazards

(These occur on the earth's land surface i.e. the continents and are generally caused by endogenetic forces)

Examples : (a) Volcanic eruptions, (b) Earthquakes, (c) Submergence and emergence, (d) Faulting,etc.

(B)Atmospheric Natural Hazards

(These are caused by atmospheric processes but affect the living organisms and non-living/abiotic components of the natural environmental/biosphere system) .

Examples: (a) atmospheric disturbances such as tropical cyclones (e. g. typhoons, tornadoes, hurricanes etc.), (b) atmospheric lighting, (c) forest fires.

(C)Cumulative Atmospheric Hazards

(These hazards are caused due to accumulation of effects of certain atmospheric phenomena for several years in continuation)

Examples: (a) floods, (b) droughts.

(ii) Man-Induced Hazards

(These hazards are caused by cumulative and even sudden effects of human activities. These are further divided into 3 sub-types and may be divided even in more sub-types)

(A) Physical Man-induced Hazards

Examples: (a) Large-scale landslides, (b) deliberate forest fires etc.

(B) Chemical and Nuclear Hazards

Examples: (a) Release of toxic elements in the air through deliberate or inadvertent human actions;

(b) sudden outburst of lethal gases from chemical factories; (c) nuclear explosions etc.

(C) Biological Hazards Induced by Man

Examples: (a) Sudden increase or decrease of population of species in a given habitat either due to increased nutrients or increased toxic elements; (b) explosion of human population.

(iii) Biological Hazards (not caused by man)

Examples: (a) locust swarms, (b) epidemics, (c) natural extinction of certain species.

2. POLLUTION

(Pollution is caused by human activities and is generally divided into two broad categories).

) Physical Pollution

(Physical pollution is caused due to lowering of the quality of physical or abiotic components of the environment by human activities and is further divided into three subtypes).

(A) Land Pollution

Examples: (a) accelerated rate of soil erosion through rill and gully erosion, (b) desertification, (c) soil pollution, (d) salinization etc.

(B) Water Pollution

Examples: Pollution of (a) seawater, (b) groundwater, (c) streams, (d) lakes etc.

(C) Air Pollution

Examples: (a) depletion of ozone layer, (b) increase in the concentration of greenhouse gases in the atmosphere, (c) decrease in the quality of air etc.

i) Social Pollution

(Pollution caused in different aspects of the society due to cumulative effects of extreme events/hazards and pollution. Social pollution may be further divided into several sub-types).

(A) Population Explosion

(B) Sociological Pollution

Examples: (a) educational and social backwardness, (b) crimes, (c) perpetual quarrels, (d) wars, (e) communal riots, etc.

(C) Economic Pollution

Examples: poverty.

1.2. CLIMATIC INFORMATION

Climate may be defined as a complex of meteorological conditions which exists in any given area and impart individually to the landscape of that area. It is perhaps the most important components of the natural environment. It affects the geomorphological process, soil formation process, plant growth and development. Climate of a place plays important role in water resources management, crop management, operations of dams and generation of hydroelectricity, planning of location of industrial sites, defence planning, tourism and transport, air pollution studies and in fact almost all spheres of human activities. The major essentials of life for mankind namely air, water, food and shelter are climate dependent. Man's various economic activities are influenced by climate in varying degrees. Climate influence man in diverse ways. Man in turn influences climate through his various activities. The modern communications media that inform us almost daily of floods, droughts, hurricanes, blizzards, heat waves, or other disasters somewhere in the world also bring news of the resulting property damage, crop failures, famine, or deaths. Dire views of the future promise global heating or cooling, changing sea level, expanding deserts and inevitable world hunger. A growing body of evidence suggests that abuse of the environment may enhance the likelihood of these catastrophes. For this reason, climatology treats the role of humankind as well as the so-called "natural" factors.

1.3: TRACE ELEMENTS

About 90 elements are found in the earth's erust out of which mere 9 elements (Viz: Al, Fe, Ca, Mg, O, Si, Na, K and Ti) only account for over 99% by weight. The remaining 81 elements together, which account for hardly 0.14% weight, constitute the so called "Trace elements". These elements, not with standing their low abundance in nature, play a vital role in plant and animal nutrition. These elements occur in living tissues in such minute amounts (or traces) that their precise concentration could not be measured by early workers with the analytical techniques then available. This is another reason why the term "Trace elements" was used to describe them. The term "Trace elements" has remained in popular use still, despite the fact that today, virtually all these elements can be estimated with great accuracy and precision with the help of modern analytical gadgets, such as neutron activation analysis, chromatography, X-ray fluorescence spectrometry, atomic spectrometry, polarography,etc.

The trace elements are classified into a sub-group known as "toxic" elements. This term may be justified for a small number of elements such as As, Pb, Cd, and Hg, the biological significance of which is at present largely confined to their toxic properties at relatively low concentrations. However, this classification has little general application because all the trace elements are toxic if ingested at sufficiently high levels and for a long enough period.

The physiological role of some essential trace metals is shown in Table- (1) from which it is clear that these have a specific function in acting as enzyme activators. In fact, it is this function that carries with in the greatest danger to the well-being of living organisms, because other non-essential elements such as Cd, Ni or Ag can replace an essential element and cause toxicity symptoms or even death in the organism. Further, it is also possible for some essential elements present in excess to displace other essential elements from their rightful function and thus producing toxic symptoms.

Table: (1) Physiological role of some essential trace metals in plants and animals.

Element	Physiological Function
Zinc	Activator for several mammalian enzymes.
Copper	Activator for several enzymes.
Chromium	Phosphoglytamase.
Cobalt	Methymalonyl GA mutase in livers, constituent of vitamin B-12.
Manganese	Activator for pyruvate corboxylase and arginase in liver.
Molybdenum	Found in metalloflavin enzymes and in xanthine oxidase in liver.

Trace elements find their way into humans either by direct absorption via air or drinking water, or via the food chain. An indispensable link in the food chain is the terrestrial or marine plant life from which humans receive their quota of trace elements directly or indirectly by feeding upon herbivorous animals which depend on plants for their nutrition. Plants absorb trace elements either via the root system or by foliar absorption.

Wherever trace elements have abnormally low-or high level concentrations, adverse effects on animals and plants in that area can be identified, and the region is said to be a "biogeochemical province." Sometimes, if a particular element is present in excess, this may result in reduced uptake of other essential elements. Uptake of trace elements via the roots of plants is generally the more important pathway of absorption and must be appreciated in order to understand the effects of pollutants upon the environment.

Out of the 105 elements discovered and confirmed so far, over 65 are metals. Owing to their high thermal and electrical conductivity, high density, high melting and boiling points, malleability, ductility and other distinctly useful properties, metals find extensive use in human civilization. According to a rough estimate, 0.5 million tones of Zn and 310 million tones of Cu have been mined so far, used for domestic and industrial purpose, and thus dispersed into the biosphere. Table-(2) shows the various heavy metals found in the effluents from some major industries.

Table – (2): Heavy metals found in the effluents from some major industries.

Industry	Heavy metals present in the effluents
Chlor-alkali	Cd, Cr, Cu, Pb, Zn, Hg, Se
Electroplating	Cu, Cr, Zn, Ni
Leather	Cr
Batteries	Pb, Cd, Hg
Paints & Dyes	Cd, Cr, Cu, Pb, Hg, Se
Textiles	Cr
Paper and pulp	Hg
Petroleum refining	Zn, Cd, Cu, Cr, Pb
Fertilizers	As, Cd, Cr, Cu, Pb, Mn, Hg, Zn
Motor Vehicles	Cd, Cr, Pb, Hg, Se, Zn
Pharmaceuticals	As, Hg

Mining and Metallurgy	As, Cd, Cr, Cu, Hg, Se, Zn
Explosives	As, Hg, Pb, Cu
Pesticides	As, Hg, Se, Pb

As stated earlier, some of the heavy metals in traces are considered to be essential for plant and animal nutrition, and they serve some useful biological function. Thus, Cu, Co, Mn, Mo, Se and Zn are essential to both plants and animals. Minute traces of As, Cr, Ni and Sn have been found to be essential for animals but not for plants. Although some essential physiological roles have been inferred for As, Cd and Pb recently, Hg and Ag have not yet been confirmed to be essential both for plants and animals since they do not seen to serve any useful biological function. However, all the heavy metals, when present in excessive quantities have been found to be toxic for animal and vegetable life. In fact, the toxicity of all the essential trace elements follow the following general trend: under-supply leads to deficiency, optimum-supply helps in health growth, and over-supply leads to toxicity and even eventual to organisms.

The adverse effects of heavy metal toxicity in biological systems may result from the following reasons:

a) interaction of the metal with protein leading to denaturation
b) interaction with DNA leading to mutation
c) effect on cell membranes
d) effect on regulatory enzymes.

The adverse effects in mammals may manifest in the following disorders:

a) Retardation of growth
b) Decrease in longevity

c) Detrimental changes in reproductive cycle leading to mortality of the offspring

d) Morbidity

e) Pathological changes

f) Symptoms of chronic disease

g) Formation of tumors.

Traces of Cu, Zn, Mn, Cr, Mo and Co have been found to be highly essential for human beings. These metals have been detected in different body organs but relatively higher levels of these metals were found in the liver. As stated earlier, higher levels of even the essential metals may lead to toxicity.

The heavy metal pollutants, like some other pollutants, on "acute" exposure (i. e. a single but relatively high dose of the toxicant) or "chronic exposure (i.e. repeated long term doses of the toxicant) severely affect different body organs. Some of the body organs are affected more severely in a poisoning situation by different chemical pollutants. The "target organs" affected by different heavy metal pollutants are given in Table: (3). below:

Table: (3) The target organs affected by heavy metal pollutants.

Heavy metal pollutant	Target Organ
(As), Hg, Mo, Se	Liver
(As), Hg, Cd, Pb	Blood
(As), Hg, Pb	Brain
(As), Hg, Cd	Lungs

(As), Hg, Pb,	Kidney
(As), Cd, Se	Bones

Excepting in case of occupational and accidental exposures, we are constantly exposed in nature to low levels of different trace metal and other pollutants.

Pb

One of the most insidious effects of inorganic lead is its ability to replace Ca in bones and accumulate there as a reservoir for long term release. This Pb is subsequently remobilize along with phosphates from the bones and exerts toxic effects when transported to soft tissues. Chronic exposure to lead cause weight loss, constipation and loss of teeth. Organic lead compounds such as tetraethyl lead can penetrate the skin and absorb into the body tissues more rapidly as compared to inorganic lead compound. Brain is the target organ for tetraethyl lead. Organo lead compounds are suspected to cause genetic modifications.

The lead-levels of urban dwellers may be as high as 200mg. Owing to the continued use of leaded gasoline, the blood-lead levels of population in major cities may vary between 2 to 35 μg/dl. The World Health Organization suggests a provisional tolerance of 7μg/kg body weight per day for adults [R-8]. The degree of inorganic lead poisoning can be indicated by determining lead content in blood, hair and urine. Leafy vegetables, potatoes and beans are likely to absorb more lead than vegetables like tomatoes, beats etc. It is better not to grow carrots, turnips, beetroot and sprouts near high ways where contamination by vehicular exhausts is more. Human activities have seriously upset the natural cycle of lead and urgent action is needed to prevent continuing and cumulative poisoning of the environment with lead. Improved plant control in smelting operations and improving the automobile engine design are suggested so that lead free gasoline can be used and at the same time emission of other pollutants like CO in the exhaust should be controlled by using suitable catalytic control devices. Immediate attention is imperative for controlling Pb pollution because in no other case the "normal levels in humans are so close to the lowest prescribed safety levels.

Cr

Trivalent chromium is found to be essential to humans and animals. It is found in small quantities in ribonucleic acid (RNA) of some organisms. It plays a vital role in insulin metabolism as the glucose tolerance factor (GTF). The supplementation of Cr (III) was found to help normalizing or improving glucose tolerance in diabetics, malnourished children and older people. Chromium is mobilized from the body stores in response to glucose administration. Trivalent chromium has a low order of toxicity. Hexavalent chromium is found to be much more toxic than the trivalent chromium. Chronic exposure to chromate dust has been correlated with increased incidence of lung cancer. Oral administration of excessive levels (50 ppm) has been associated with liver and kidney damage and depression in experimental animals [R-9]. Exposure to hexavalent chromium causes allergic skin irritations, dermatitis, irritation to mucous membranes and conjunctiva and gastrointestinal ulcers chrome holes i.e. penetrating ulcers which occur around the fingernails, the surface exposed finger joints, eyelids and occasionally on forearms.

Cu

Laboratory studies have shown several physiological functions involving copper. Defects in pigmentation, bone formation, reproduction, myelination of the spinal cord, cardiac function and connective tissue formation, in addition to defects in growth and hematopoiesis were found to be the manifestations of copper deficiency. Excessive intake of Cu may cause hemolysis, hepatotoxic and nephrotoxic effects. Inhalation of air-borne copper causes irritation of the respiratory tract and metal fume fever. Workers involved in use of fungicides containing copper sulphate develop a respiratory disorder called "vineyard sprayer's lung" which is characterised by the development of interstitial pulmonary lesions and nodular fibro-hyaline scars. This may lead to even lung cancer.

Copper poisoning can occur as an industrial hazard in workers engaged in copper mining or processing. Continuous ingestion of Cu from food or water at intakes sufficient to induce chronic copper poisoning in man is unlikely. "Wilson's disease" (or hepatolenticular degeneration), which is characterised by excessive concentrations of Cu in the tissues, arises from metabolic defects involving absorbed Cu and not from the ingestion of excessive amounts of Cu. Other conditions which manifest increased Cu content in liver include thalassemia, cirrhosis, atrophy of liver, tuberculosis, hemachromatosis and carrcinoma.

Ni

Nickel is essential in animal nutrition. Significant concentrations of Ni have been shown to be present in RNA and DNA. Ni is shown to be essential for some micro-organisms and animals but not to plants. It is associated with the synthesis of vitamin B-12. It is toxic at higher concentrations.

Ni is found to be toxic for most plants and fungi. Growth of woody plants was hindered by high nickel concentrations in the soil. Land plant tissues contain about 4 times more nickel than in animal tissues.

Emission of nickel into the atmosphere by burning of fossil fuels is estimated to be 70,000 tones per year on global basis [R-10]. Nickel is found in tea, cocoa, peanuts and several other foodstuffs.

Co

Cobalt is an essential element for humans and animals because it is associated with the synthesis of vitamin B-12. Cobalt is used in the manufacture of alloys, permanent magnets, paint driers and as industrial catalyst in processes such as manufacture of NH_3 and alcohol. Cobalt salts are used in the treatment of anemia and cyanide poisoning. Instant coffee and tea contain considerable amounts of Co. Ingestion of excessive amounts of cobalt causes intercellular hypoxia and polycythemia. chronic exposure of cobalt may lead to goitre.

Mn

Manganese is an essential trace element but is toxic at higher concentrations. A daily intake of 2.5 to 5 mg of Mn by humans contributes to the well being of the cells because it acts as a co-factor in some enzymatic reactions such as those involved in Phosphorylation, Synthesis of fatty acids [R-11]. However, when exposed to higher levels of Mn, it gets accumulated in kidney, liver and bones and cause "Manganese psychosis," which is an irreversibly brain disease characterised by uncontrollable laughter, euphoria, impulsiveness, sexual excitement followed by impotency, etc. Mn is among the least toxic metals to plants. High concentrations of Mn may be toxic, particularly in acidic soils. It generally affects plant tops than roots. Accumulation of Mn in leaves leads to chlorosis and necrosis of leaves.

Human beings get their daily quota of maganese from vegetables, grains, fruits, nuts, etc.

Zn

The role of zinc as an essential nutrient is well established now. A number of enzymes including aldolase, alkaline phosphatase, alcohol dehydrogenase, carboxy peptidase, carbonic anhydrase are dependent on Zn. Zinc is also present in co-factor of other enzymes such as arginase and diaminase. Thus, it takes part in the synthesis of DNA, proteins and insulin. Hence, Zn is essential for the normal functioning of the cells including protein synthesis, carbohydrate metabolism, cell growth and cell division.

A normal human body contains 1.4 to 2.3 g of Zn and it is present in all body cells[R-12]. Highest Zn concentrations are found in eye, prostate, liver kidney, muscle, heart, skin and pancreas. Zinc influences growth rate and bone development. The Zn deficiency syndrome manifests itself by retardation of growth, anorexia, lesions of skin and appendages, impaired development.

1.4. REVIEW OF PREVIOUS WORK.

The measurement of environmental parameters such as humidity, rainfall, temperature, sunshine hour, wind speed, dew temperature, soil temperature, radiation level, trace elements have been done in several countries as well as in our country, and the result on it has been reported in many Journals. Thus a review of such works were carried out by searching some available reports/journals for the period 1976 to 1998 and the summarized description of the works of the respective authors are given below:

(1) Manalo (1976) [R-13]:

Carried out a detailed study of rainfall and other climatic parameters using available data from different climatic stations in Bangladesh. In this report the author described the characteristic features of the climatic regimes of the country for evaluating the potentialities of cropping system. The results of the study were presented in the form of isohyetal maps representing mean annual rainfall, mean monthly rainfall, mean seasonal (June-October) rainfall,number of months with rainfall between 100 mm to 200mm, etc. The author also prepared histograms of the monthly rainfall for various regions of the country.

(2) Khan (1976) [R-14]:

Estimated rainfall probabilities for 2-week running period using daily rainfall data with 36 years of records for the period 1934 to 1969 from 13 different locations. This study was directed towards agricultural applications, e.g.

designing of proper cropping pattern and for determination of the capacity of supplementary irrigation system.

(3) Yung Ho Kang (1978) [R-15]:

Determined the radioactive contamination level in Korean food stuffs which were grown in central district: Honam district, Youngnam district, Jeju Island, Ulnung Island, Sr-90 concentration in vegetables of the Honam district samples and Jeju Island samples were much higher than in other districts. These tendencies were due to geographical and meteorological conditions.

(4) Sadeq, M. (1985) [R-16]:

Carried out a study of uptake of Cd, Pb and Ni by corn grown in contaminated soils in Saudi Arabia. Sixteen calcareous soil samples were spiked with Cd, Pb and Ni. Corn plants were analyzed for Cd, Pb Ni. Total and DTPA extractable concentrations of the above metals were also determined in the experimental soils. In corn, Cd accumulated in higher amounts followed by Pb and Ni. The concentrations of Cd in corn were significantly correlated to the DTPA extractable Cd in the soil samples. There was no significant correlation between the concentration of Ni and Pb in the corn and the DTPA-extractable levels of these metals in the experimental soils.

(5) **Mukherjee et. al. (1987) [R-17]:**

Studied the applicability of extreme value type I (EVI) distribution of annual maximum rainfall series over different parts of India. In this study it is observed that EVI distribution is generally applicable to annual maximum rainfall in major parts of India.

(6) **Islam, M. A. et. al. (1989) [R-18]:**

Measured the relative activity in soil and sand of the Padma river bed and Rajshahi City. A high relative exposure due to the sand of the Padma was found. The activity of the soil samples of Rajshahi City in general was found to be similar with that of other district with some exceptions.

(7) **Khan, Tarafdar, Ali, Biswas, Akhter, Saha, Islam, Billah, Hadi, Maroof (1989) [R-19]:**

Investigated the status of trace and minor elements in some Bangladeshi foodstuffs. This investigation is done by using PIXE and XRF techniques. The results indicate that none of the food (cereals, vegetables, milk egg and fish) regimes investigated here is burdened with heavy metals beyond permissible limits except five species of vegetables with chromium having the range of 0.99-3.59 mg/kg compared to the literature value of 0.0-0.36 mg/kg. An average value of 0.2 mg/kg of arsenic was observed both in IRRI and local Aman varieties of rice and only one hen egg contained 1.7mg/kg of lead in yolk. The zinc content in some marine fish from the Bay of Bengal was reported to be 5.4-19.5 mg/kg, whereas in the present study of sweet-water fish, the level is found to be 15.2-62.1 mg/kg for five species. In human milk, both Cu(0.12-0.25mg/l,) and Zn (0.28-1.80mg/l,) levels appear to be almost half the literature values.

(8) **Bose, S. R and Rahman, L (1990)[R-20] :**

Determined the trace elements in soil and rice plant in some areas of Bangladesh. A comprehensive survey of soil and rice tissue was made for the districts of Faridpur, Barishal, Noakhali, Chittagong in order to find out the status of trace elements with special reference to Zn deficiency. It was observed that most of the collected soil samples are deficient in Zn when 3 ppm Zn was considered as deficient level. The plant Zn content in the samples collected from the location from where the soils were collected showed nearly 70% as Zn deficient when 20 ppm was considered as the critical limit.

9. **Iqbal, M. and Zobeida (1991) [R-21]:**

Studied the effect of greenhouse warming on the summer monsoon in Bangladesh. The recent changes in climatic behaviour of Bangladesh are the outcome of greenhouse effect, active especially on the nature and characteristics of the summer monsoon, which show some inconsistencies prevailing in its traditional way of arrival and withdrawal.

(10) **Haque, M. M. et. al (1993) [R-22]:**

Determined the radiation level in fruits grown around Rajshahi region. The activity of Cs - 137 in the fruits varied between 30 p Ci/Kg to 393 pci/kg of fresh weight. The activities of K- 40 contents in the fruits ranged from 54 pci/kg to 546 pci/kg of fresh weight. It showed that the concentration of K-40 is more than the concentration of Cs - 137 in most cases.

(11) **Matin, M. A. et. al (1993) [R-23]**

Performed a study of background radiation levels in different parts of Rajshahi City. Some of the areas were observed to contribute to the increased radiation level and some others were observed to contribute to the decreased radiation level with rainfall. The range of the background radiation level over the city was observed to be 0.018 ± 0.0016 mR/hr to 0.042 ± 0.0016 mR/hr.

(12) **Haque, M. M. et. al (1995)[R-24]:**

Measured the soil activity of different gamma emitting radionuclides in Godagari thana region under Rajshahi district. The integrated activities of Tl-208, Bi-214 and Cs-137contained in the soil was found to have on average value of 1.9242 ± 0.0712 pci/gm at depth 0″ to 5″ and 1.4632 ± 0.0566 pci/gm at depth 5″ to 10″. The average activity of K-40 was observed to be 1.9322 ± 0.1010 pci/gm at 0″ to 5″ depth and 1.6205 ± 0.0933 pci/gm at 5″ to 10″.

(13) **Suren, Mahabub and Zahid (1995) [R-25]:**

Performed a study of effective rainfall for irrigated agriculture in Bangladesh. It has been observed that as the distance from sea increases the value of effective rainfall percentage also increases, except for the north-eastern part of Bangladesh. While designing an irrigation project, optimum utilization of irrigation water can be achieved by using the effective rainfall values.

(14) **Hadi, Tarafdar, Akhter, Younus (1995) [R-26]:**

Determined the status of Pb, Cd, Zn and Cu in a few Bangladeshi vegetables. In the present study, the levels of Cd, Pb, Cu and Zn were found to be in the range of 0.11-1.17, 0.90-7.73, 3.27-26.13 and 11.47-172.02 μ/g respectively.

(15) **Zabid, Shahria and Mehdi (1996) [R-27]:**

Carried out a study of climatological patterns in Nepal. According to Koppen classification, the north, north east and north west part of Nepal, ranging form west to east falls under "Tropical upland Mild winter; dry winter; short warm summer" type and the remaining part enjoys 'subtropical monsoon, mild winter; dry winter' type climate.

(16) **Saha, B. K. et al (1997) [R-28]:**

Measured the environmental radiation in Rajshahi City by Thermoluminescence Dosimetry (TLD) and Gamma spectrometry. The dose rate obtained from the gamma spectrometry was solely from U-series, Th-series and K-40 radionuclides, but the TLD dose rates were from all the natural gamma radiations including U-series, Th-series and K-40 radionuclides of the environment.

(17) **Khair, Alam, Ratan (1997) [R-29]:**

Studied the climatic pattern of Bangladesh. This study deals with some available climatological data for 38 stations in Bangladesh from 1961 to 1980. Based on precipitation effectiveness (PE), the south-eastern part and north-eastern part of Bangladesh, whose the annual rainfall is high, fall in the perhumid zone and the remaining part fall in humid zone.

(18) **Ahmed, S. (1997) [R-30]:**

Performed a study to analyse trace elements in Barapukuria coals. Trace elemental analysis using PIXE spectroscopy determines about 19 elements in

Barapukuria coals whose concentration are determined and compared with those of some Canadian coals. The concentrations of some major elements of some major elements like K, Ca, Mn, Fe and some trace elements like As, Cu, Ni, Se etc. in the Barapukuria coals are found to lie within their respective range in the Canadian coals. The concentrations of Br, Co, Ga, Rb etc are higher than their respective values in the Canadian coals.

(19) **Haque, M. M. et. al. (1998) [R-31]:**

Determined the environmental radioactivity level in the soil of some areas in Rajshahi, Naogaon and Nawabganj districts of Bangladesh. The average activities of U-238, Th-232, Th- 228 K-40 and Cs-137 in the soil samples of Tanore thana of Rajshahi district were found to be 42.18 ± 6.45, 47.00 ± 9.2, 73.77 ± 10.5, 277.11 ± 55.07 and 3.35 Bq/Kg respectively.

(20) **Shakauat, Dipok and Ramkamal (1998) [R-32]:**

Studied the climate of Bangladesh. In January, the country experiences lowest mean temperature and highest in May. The country receives about 60% to 80% of its annual rainfall during the southwest monsoon season.

1.5. MOTIVATION OF THE PRESENT WORK.

Eversince the start of life on earth it is trying to adjust itself with the environment as it is slowly changing due to so many natural causes. In addition to these man is also responsible for the pollution of the environment while trying to change the environment for his needs and comfort. For example, metals and metalloids have long been mined, industrially processed and used in numerous applications. This has led, specially since the industrial revolution and during the 20^{th} century, to regional and global redistribution and for some more or less, hazardous elements to a significant increase of their concentrations in the upper part of earth's crust causing pollution of environment. Therefore in the plough layer of soil, in plants, animals, lakes, rivers also even in ocean and artic regions, in foodstuffs and human beings the levels of a variety of elements have substantially increased over time. Atomic explosions have also increased some of these elements including many radioactive ones.

Extensive mining, land use, cutting trees, making barrages, atomic explosion etc. are also changing the weather causing problem to human being. As a result, unless we restrict ourselves in these regards locally as well as globally it will be impossible to maintain a congenial living environment for ourselves.

There has been a rapid rise in the amount of total data in the environmental science. However much more needs to be known, regarding the distribution in the environment of metal specimens. It is the form of the metals and not their concentrations which determines its bioavalibility, toxicity, and more of interactive with biological and other environmental elements. Unfortunately, except in few cases such as mercury, elemental specification data are sparse. It is often difficult to obtain data on the form of metals in complex environmental samples.

In Bangladesh regular monitoring of some of the weather parameters (like, temperature, relative humidity, dew temperature, rainfall, wind speed, soil temperature, sunshine hour) are being done at different weather stations. Also elemental analyses has been done in the form of trace in foodstuffs collected from some local area.

However, no extensive works in these regards have been done at Rajshahi. So the present work was undertaken to measure

(1) some of the weather parameters and

(2) trace elements in some winter vegetables collected from Rajshahi City market.

This improved knowledge of some weather parameters and metal specification, in environmental materials over a large number of years is expected to improve our ability to interpret and predict the environmental behavior at Rajshahi. And this may help us to take some possible measures for controlling pollution of our environment.

Chapter - 2

Measurements of Different Climatic Parameters

2.1. Humidity:

Humidity is defined as the ratio of the amount of water vapour in the air at any temperature to the amount of water vapour that air can hold at that temperature. Stated briefly humidity is the ratio of the air's water vapour content to its water vapour capacity. This ratio is always expressed as a percentage. Humidity is of major interest to the geographers because of its importance for human comfort and for plant growth.

Measurement Technique:

Humidity is usually measured by the Dry-bulb-Hygrometer. It consists of two glass thermometers one of them called a Wet-bulb-thermometer and the other the Dry-bulb thermometer. The Wet-bulb thermometer has its mercury bulb wrapped in a wick. The other end of the wick is submerged in a container of distilled water which ensures a continuous moisture supply to the Wet-bulb thermometer through the effect of surface tension. The Dry-bulb temperature records the ambient air temperature denoted by T_d. The thermometers are ventilated by whirling. Because of the cooling effect of evaporation the Wet-bulb thermometer reads a temperature T_w, which is always lower than the Dry-bulb temperature. The difference between the two, that is $(T_d - T_w)$, is known as the Wet-bulb depression. From the measured values of T_d, $(T_d - T_w)$, the humidity can be obtained from the Hygrometric Table (4).

In the present work, 5 years (1995-1999) month wise humidity of Rajshahi City were measured and these are shown in Table (5) These measured data are also presented graphically as shown in Fig (10-14).

The photograph of Hygrometer is shown in Fig (1).

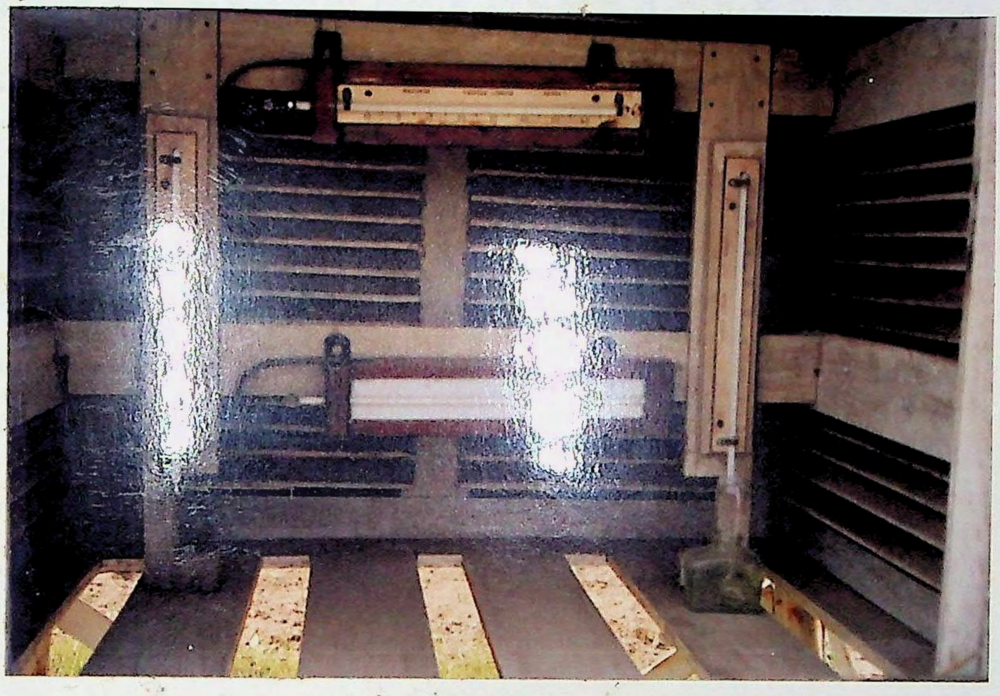


Fig-1 Photograph of Hygrometer/Mercury in Glass type thermometer.

Table-4: Hygrometric

Dry-bulb temp. (°C)	Wet-bulb depression ($T_d - T_w$) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
-20	28																					
-18	40																					
-16	48	0																				
-14	55	11																				
-12	61	23																				
-10	66	33	0																			
-8	71	41	13																			
-6	73	48	20	0																		
-4	77	54	32	11																		
-2	79	58	37	20	1																	
0	81	63	45	28	11																	
2	83	67	51	36	20	6																
4	85	70	56	42	27	14																
6	86	72	59	46	35	22	10	0														
8	87	74	62	51	39	28	17	6														
10	88	76	65	54	43	33	24	13	4													
12	88	78	67	57	48	38	28	19	10	2												
14	89	79	69	60	50	41	33	25	16	8	1											
16	90	80	71	62	54	45	37	29	21	14	7	1										
18	91	81	72	64	56	48	40	33	26	19	12	6	0									
20	91	82	74	66	58	51	44	36	30	23	17	11	5	0								
22	92	83	75	68	60	53	46	40	33	27	21	15	10	4	0							
24	92	84	76	69	62	55	49	42	36	30	25	20	14	9	4	0						
26	92	85	77	70	64	57	51	45	39	34	28	23	18	13	9	5						
28	93	86	78	71	65	59	53	47	42	36	31	26	21	17	12	8	4					
30	93	86	79	72	66	61	55	49	44	39	34	29	25	20	16	12	8	4				
32	93	86	80	73	68	62	56	55	46	41	36	32	27	22	19	14	11	8	4			
34	93	86	81	74	69	63	58	52	48	43	38	34	30	26	22	18	14	11	8	5		
36	94	87	81	75	69	64	59	54	50	44	40	36	32	28	24	21	17	13	10	7	4	
38	94	87	82	76	70	66	60	55	51	46	42	38	34	30	26	23	20	16	13	10	7	5
40	94	89	82	76	71	67	61	57	52	48	44	40	36	33	29	25	22	19	16	13	10	7

Table – 5 : Monthly mean humidity in %.

Year / Month	1995	1996	1997	1998	1999
January	76	87	88	80	76
February	76	82	62	60	41
March	63	77	60	53	48
April	59	65	58	93	65
May	72	92	55	60	79
June	86	95	64	86	83
July	90	97	75	88	88
August	89	96	82	88	87
September	89	92	88	89	84
October	84	88	70	81	
November	93	85	79	79	
December	80	82	98	78	
Yearly mean	79.75	86.5	73.25	77.91	77.33

2.2 Rainfall:

Rainfall is defined as water in liquid or solid forms falling to the earth. Rainfall is deposition of atmospheric moisture and is perhaps the most important phase of the hydrologic cycle. Atmospheric moisture may be precipitated either in solid or liquid states. Rain, snow, hail and sleet, etc. are the common forms of condensed moisture, namely, fog, dew and frost. It is a product of some climatic phenomena as evaporation, condensation, vapour pressure and formation of cloud etc. It is one of the dominant factors in the assessment of climatic water balance region. As it governs humidity and aridity of a region, and consequently the agricultural efficiency, it secures the first place in the practical importance.

Measurement Technique:

Rainfall is measured by Float type Raingauge. This type of raingauge is also known as the Siphon type raingauge as it uses the siphon mechanism to empty the rainwater in the float chamber. The details of construction of this type of raingauge are shown in Fig (2). Rain water entering the gauge at the top is led into the float chamber through a funnel and filter. The purpose of the filter is to prevent dust and other particles from entering the float chamber which may hinder the siphon mechanism. The float chamber consists of a float with a vertical stem protruding outside, to the top of which a pen is mounted. This pen rests on a chart secured around a clock driven drum. There is a small compartment by the side of the float chamber which is connected to the float chamber through a small opening at the bottom. This is called the siphon chamber which houses a small vertical pipe with bottom end open and the top end almost touching the top of the chamber. During the storm the rain water collected in the float chamber raises the water surface in it and along with the water surface the float also rises enabling the pen to make a trace of cumulative depth of rainfall on the chart. When the float chamber is completely filled with water, the pen reaches the top of the chart. At this instant the siphoning occurs automatically through the pipe in the siphon chamber, the float chamber is emptied and the pen is brought to zero on the chart again. As the rain continues the pen rises again from the zero on the chart. The complete siphoning should be over in less than 15 second of time. This gauge cannot record precipitation in the form other than rain unless some sort of heating device is provided inside the gauge. The float may be damaged if the rainfall catch freezes.

Monthwise data for 5 years (1995-1999) rainfall of Rajshahi city are shown in Table (6). These data are also presented graphically as shown in Fig (10-14). Hythergraph of Rajshahi are shown in Fig (15-19)

The photograph of raingauge is shown in Fig (3).

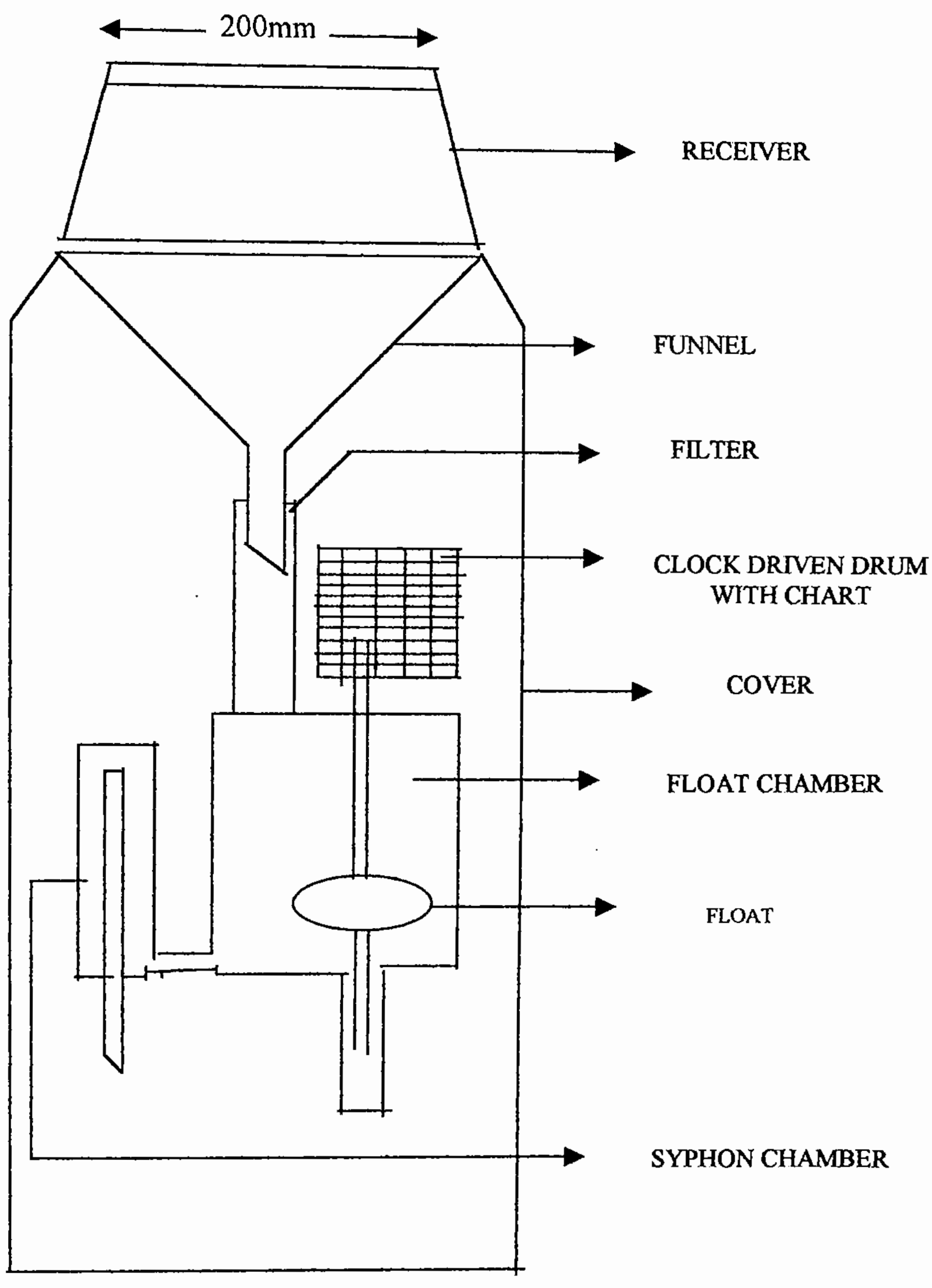


Fig-2: Float type rainguage.

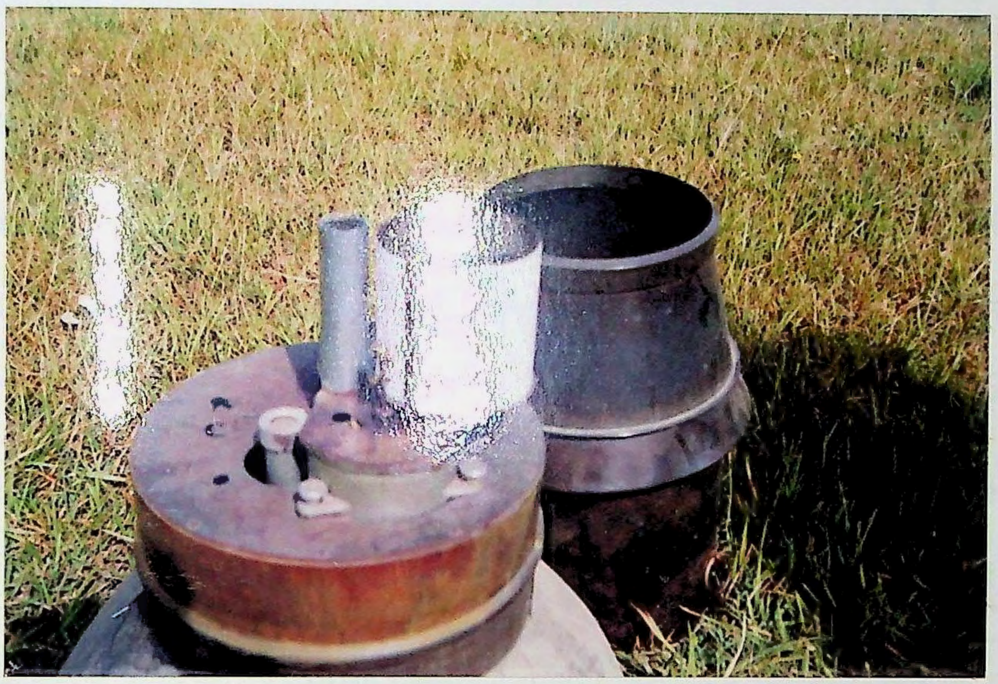


Fig-3 Photograph of Raingauge

Table – (6)

Monthly mean rainfall in m. m.

Year / Month	1995	1996	1997	1998	1999
January	18	-	04	16	-
February	32	20	31	05	-
March	14	04	19	51	-
April	18	73	55	33	09
May	64	95	53	129	144
June	235	284	242	92	348
July	414	106	765	404	349
August	287	257	463	286	345
September	296	305	381	285	502
October	06	125	03	198	
November	60	-	44	33	
December	-	-	22	-	
Yearly mean	120.33	105.75	173.5	127.66	188.55

2.3 Temperature:

Temperature refers to the intensity of energy present in a substance, i.e. the degree of hotness. Temperature is an independent parameter among the climatic elements whose variation causes corresponding changes in the pressure distribution and consequently in the direction of wind as well as its velocity which controls atmospheric humidity, condensation, formation of cloud and their drafting in the sky, precipitation and storms. As far as the climatic study of an area is concerned, temperature plays an important role because it determines the character of local climate. There is none which practices so profound a control over human distributions.

Measurement Technique:

The temperature is usually measured with Mercury-in-Glass type of thermometer in degree Celsius (°C). The thermometer is placed in a standard instrument shelter, called Stevenson Screen, whose purpose is to see that relatively unobstructed air circulation is there around thermometers and at the same time the thermometers are protected from the direct rays of the sun and from precipitation.

In the present work, 5 years (1995-1999) monthly mean temperature of Rajshahi City were measured and these are shown in Table (7) and Monthly maximum and minimum temperature are shown in Table- (8) & (9) respectively.

The graphical representation of these data are shown in Fig (10-14) Hythergraph of Rajshahi are shown in Fig (15-19). The photograph of thermometer is shown in Fig (1)

Table – (7): Monthly mean temperature in °C.

Year / Month	1995	1996	1997	1998	1999
January	15.60	17.70	17.25	18.40	18.22
February	19.00	17.70	19.00	18.50	22.75
March	25.65	26.85	23.50	21.70	26.44
April	29.65	30.00	26.75	27.90	30.95
May	32.55	30.20	31.50	26.50	29.68
June	30.70	29.00	31.5	31.00	30.30
July	29.25	29.65	30.90	29.70	29.16
August	29.55	29.20	29.95	29.80	29.06
September	28.85	29.55	27.50	29.40	28.45
October	27.00	26.75	26.85	28.70	
November	21.75	22.90	23.00	25.10	
December	19.10	19.20	21.60	20.45	
Yearly mean	25.72	25.72	25.77	25.59	27.22

Table – (8): Monthly highest maximum temperature in °C

Year / Month	1995	1996	1997	1998	1999
January	26.5	24.4	24.5	24.6	24.83
February	29.6	24.3	27.0	26.0	30.16
March	39.8	34.2	30.5	30.4	35.18
April	42.2	37.5	34.0	35.0	37.0
May	43.3	35.8	37.0	32.0	34.6
June	38.6	33.0	35.7	35.3	34.3
July	34.2	33.3	34.5	32.8	32.22
August	34.8	32.4	32.5	32.8	32.06
September	34.5	33.0	31.0	32.6	31.27
October	34.6	31.0	32.0	32.4	
November	33.0	29.3	29.4	29.8	
December	28.4	26.1	25.6	26.8	
Yearly mean	34.95	31.19	31.14	30.87	32.40

Table – (9): Monthly lowest minimum temperature in °C

Year / Month	1995	1996	1997	1998	1999
January	4.7	11.0	10.0	12.2	11.6
February	8.4	11.1	11.0	11.0	15.33
March	11.5	19.5	16.5	13.0	17.69
April	17.1	22.5	19.5	20.8	24.81
May	21.8	24.6	26.0	21.0	24.83
June	22.8	25.0	27.3	26.7	26.33
July	24.2	26.0	27.3	26.6	26.1
August	24.3	26.0	27.4	26.8	26.06
September	23.2	26.1	24.0	26.2	25.63
October	19.2	22.5	21.7	25.0	
November	10.5	16.5	16.6	20.4	
December	9.8	12.3	17.6	14.1	
Yearly mean	16.45	20.25	20.40	20.31	22.04

2.4 Bright Sunshine Hour

Bright sunshine is defined as the intensity of sunlight which is sufficient to cast a shadow. Even though a thin overcast covers the sun, it can cast a shadow. Light is necessary for photosynthesis. An intensity of 1500-2500 foot candles is usually sufficient. Increasing the intensity does not significantly affect photosynthesis.

Measurement Technique:

The duration of bright sunshine in a day is recorded by an instrument called a Sunshine Recorder. It consists of a hemispherical glass dome underneath which a chart is placed. As the sun's rays are always directed towards the centre of the dome the intense heat developed there will make a black mark by burning the chart when there is bright sunshine. When the sky is cloudy such mark will be absent. The length of the chart which has the burnt mark would indicate the duration of sunshine.

Monthwise data for 5 years (1995-1999) of bright sunshine hours of Rajshahi City are shown in Table- (10).

Graphical representation of these data are shown in Fig-(25-29).

The photograph of Sunshine Recorder is shown in Fig- (4).

Fig-4 Photograph of Sunshine Recorder

Table – (10): Monthly sunshine hour in hour

Year / Month	1995	1996	1997	1998	1999
January	7.13	7.06	6.96	5.06	8.14
February	7.86	8.46	8.36	7.10	9.57
March	7.66	8.50	8.73	8.53	9.77
April	8.86	8.33	7.60	8.26	8.73
May	6.43	7.90	9.20	7.36	6.73
June	3.93	5.76	7.17	5.84	5.17
July	3.53	4.63	5.33	3.86	4.16
August	3.77	4.80	4.90	4.23	4.2
September	3.77	6.33	5.30	5.96	4.97
October	7.76	8.06	8.56	6.66	
November	6.63	9.43	7.33	8.03	
December	8.13	8.83	6.13	8.47	

2.5. Wind Speed

As a climatic element , wind is of greater importance especially when it blows strongly. The influence of wind on other components of weather and climate namely temperature and precipitation is more important. The heat and moisture from a distance are transported by wind , cause storms, clouds, rain, snow, hot spells, sudden freezes etc. As the rate of evaporation is influenced by wind , they also affect sensible temperature. By no means the wind is independent of other components. They tend to produce uniformity of climates over extensive areas, unless obstructed by mountain barriers present in their way.

Measurement Technique:

Wind speed is measured by the Cup Anemometer. It consists of 3 or 4 hemispherical cups fixed in a horizontal plane to a sleeve which can freely rotate about a vertical axis. The rotation is transmitted to a gauge, mounted under the cups, which counts the number of revolutions. The counter is so designed that the increase in reading of the counter divided by the intervening time interval in hours gives the wind speed directly in km/h.

Monthwise data for 5 years (1995-1999) of wind speed of Rajshahi City are shown in Table- (11).

These data are also presented graphically as shown in Fig - (30-34).

The photograph of Cup Anemometer is shown in Fig (5).

Fig-5 Photograph of Cup Anemometer

Table – (11): Monthly wind speed in nautical miles/hour.

Year / Month	1995	1996	1997	1998	1999
January	2.10	2.42	2.90	2.49	3.48
February	1.90	3.03	3.21	2.68	3.78
March	2.00	3.09	3.51	3.35	3.51
April	2.30	4.70	5.06	4.31	4.50
May	3.00	3.87	5.03	5.77	6.00
June	2.50	6.83	5.47	5.33	4.83
July	4.40	3.16	4.03	4.48	4.06
August	3.00	3.41	4.35	4.16	3.64
September	3.60	2.80	2.77	4.23	4.2
October	1.80	2.58	1.90	2.56	
November	1.70	2.76	1.83	3.50	
December	1.60	3.22	2.80	3.55	

2.6. Dew Temperature:

Dew consists of tiny droplets of water produced by condensation on surface objects rather than on nucleic in the air above the surface. Any nature observer will find in the morning shining beads of water droplets deposited on leaves and blades of grass. In fact, dew refers to " water drops deposited by direct condensation of water vapour from the adjacent clear air mainly on horizontal surfaces cooled by nocturnal radiation" [R-33].

Cole [R-34] defines dew as the "Condensed moisture that forms in place as a consequence of contact cooling".

Clear sky and calm air are necessary conditions for the formation of dew. Clouds act as blankets which greatly reduce the radiation cooling during night. Movement and turbulence in the lower stratum of atmosphere cause mixing and thereby prohibit the air from reaching its dew point. That is why windy nights do not favour the formation of dew.

Measurement Technique:

Dew temperature is usually measured by the Hygrometer. It consists of two glass thermometers one of them called a wet bulb thermometer and the other the dry bulb thermometer. The wet bulb thermometer has its mercury bulb wrapped in a wick. The other end of the wick is submerged in a container of distilled water which ensure a continuous moisture supply to the wet bulb thermometer through the effect of surface tension. The dry bulb temperature records the ambient air temperature denoted by T_d. The thermometer are ventilated by whirling. Because of the cooling effect of evaporation the wet bulb thermometer reads a temperature T_w, which is always lower than the dry bulb temperature. The difference between the two, that is $(T_d - T_w)$, is known as the wet bulb depression. From the measured values of T_d, $(T_d - T_w)$, the dew temperature can be obtained from the Hygrometry Table – (12)

Assuming dry bulb temperature and wet bulb temperature of 26°C and 20°C respectively and the atmospheric pressure as 1000mb, the dew temperature is measured as follows.

$$T_d = 26°C$$

$$T_w = 20°C$$

$$(T_d - T_w) = (26°C - 20°C) = 6°C$$

From Hygrometry Table, the dew temperature is 17°C.

For the present work, 5 years (1995-1999) Monthwise dew temp.of Rajshahi City were measured and these are shown in Table- (13).

These data are also presented graphically as shown in Fig- (35-39)

The photograph of Hygrometer is shown in Fig –(1).

Table-12: Hygrometric
Atmospheric pressure (1,000 mb)

Dry-bulb temp. (°C)	Wet-bulb depression ($T_d - T_w$) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
-20	-33																					
-18	-28																					
-16	-24																					
-14	-21	-36																				
-12	-18	-28																				
-10	-14	-22																				
-8	-12	-18	-29																			
-6	-10	-14	-22																			
-4	-7	-11	-17	-29																		
-2	-5	-8	-13	-20																		
0	-3	-6	-9	-15	-24																	
2	-1	-3	-6	-11	-17																	
4	1	-1	-4	-7	-11	-19																
6	4	1	-1	-4	-7	-13	-21															
8	6	3	1	-2	-5	-9	-14															
10	8	6	4	1	-2	-5	-9	-14	-28													
12	10	8	6	4	1	-2	-5	-9	-16													
14	12	11	9	6	4	1	-2	-5	-10	-17												
16	14	13	11	9	7	4	1	-1	-6	-10	-17											
18	16	15	13	11	9	7	4	2	-2	-5	-10	-19										
20	19	17	15	14	12	10	7	4	2	-2	-5	-10	-19									
22	21	19	17	16	14	12	10	8	5	3	-1	-5	-10	-19								
24	23	21	20	18	16	14	12	10	8	6	2	-1	-5	-10	-18							
26	25	23	22	20	18	17	15	13	11	9	6	3	0	-4	-9	-18						
28	27	25	24	22	21	19	17	16	14	11	9	7	4	1	-3	-9	-16					
30	29	27	26	24	23	21	19	18	16	14	12	10	8	5	1	-2	-8	-15				
32	31	29	28	27	25	24	22	21	19	17	15	13	11	8	5	2	-2	-7	-14			
34	33	31	30	29	27	26	24	23	21	20	18	16	14	12	9	6	3	-1	-5	-12	-29	
36	35	33	32	31	29	28	27	25	24	22	20	19	17	15	13	10	7	4	0	-4	-10	
38	37	35	34	33	32	30	29	28	26	25	23	21	19	17	15	13	11	8	5	1	-3	-9
40	39	37	36	35	34	32	31	30	28	27	25	24	22	20	18	16	14	12	9	6	2	-2

Table – (13): Data for Dew temperature in °C.

Year / Month	1995	1996	1997	1998	1999
January	12.24	13.80	13.56	13.46	13.22
February	15.07	16.01	16.06	17.00	15.70
March	17.32	20.50	18.31	15.81	15.62
April	21.27	17.15	21.75	21.50	23.87
May	24.27	25.10	23.25	25.75	25.30
June	26.22	25.40	25.24	27.74	26.20
July	26.62	26.50	26.75	27.24	26.57
August	26.73	26.90	26.94	27.25	26.68
September	24.92	24.78	25.62	26.50	26.01
October	22.92	24.12	22.69	23.87	
November	19.89	19.02	19.44	21.18	
December	15.97	14.96	16.25	15.18	

2.7. Soil Temperature:

Temperature plays an important role in different kinds of organic and inorganic chemical reaction of soil. Like water and air, temperature is essential for the crop and nutrition. Trees and plants fail to grow properly if the heat is less than 41°F. The seeds are not sprouted without sufficient heat. Acceptable nitrogen, phosphorus and sulpher remain a little in the soil for low temperature. The rate of subtraction of the organic matter, the nitrate transformation in dissolving process, the rate of food process in ion state increase in high temperature. The soil temperature depends upon two conditions. They are –

1. Heat absorbing power of soil,
2. Rate of evaporation.

Sun is the main source of soil temperature. How much sun light or sun heat the soil can absorb that depends upon how much heat that come form the sun on earth. On the average about 50% sun ray comes to the earth. Rest of them reflecting by the cloud goes back to the sky. In dry season, if the sky is not cloudy, 75% sun ray comes to the earth. But it comes only 35%-40% in the cloudy atmosphere. The sun ray that comes to the earth is not utilized fully. Of them 30% - 45% reflecting from the earth go back to atmosphere. 5% is used in photosynthesis process of the trees. If the soil is not dry, 5% - 15% sun ray is stored as heat in the soil and trees.

Measurement Technique:

The soil temperature is usually measured with Mercury-in-Glass type of thermometer in degree Celsius (°C). Two thermometers are inserted into the soil in twodepth 10 cm and 30cm.

For the present work, 5 years (1995-1999) monthly soil temperature of Rajshahi City in two different depth of soil was measured and these are shown in Table (14).

The graphical representation of these data are shown in Fig- (40-44).

The photograph of thermometers is shown in Fig (6).

Table 14: Monthly data for soil temperature in °C.

Year	1995		1996		1997		1998		1999	
Month	10cm	30cm	10cm	30cm	10cm	30cm	10cm	30cm	10cm	30cm
January	17.12	18.66	17.25	18.15	16.23	18.30	17.00	18.27	16.93	18.97
February	19.50	20.66	20.40	20.47	19.70	20.20	20.53	21.20	21.73	22.01
March	25.95	24.73	26.67	25.63	26.13	25.23	24.33	24.37	26.93	26.43
April	22.50	21.70	31.10	29.87	28.10	27.83	28.80	28.63	32.58	31.18
May	32.50	33.00	32.30	31.60	32.17	31.60	31.47	31.07	32.10	32.00
June	31.25	32.9	29.90	30.77	31.87	31.70	32.60	32.63	31.96	32.30
July	30.57	31.03	31.67	31.40	30.93	30.73	31.47	31.63	30.57	30.83
August	31.12	30.63	31.83	31.04	31.40	31.43	31.97	32.10	30.73	31.13
September	29.75	30.73	30.73	31.03	30.77	30.87	31.03	31.43	30.00	30.33
October	27.95	29.00	28.17	29.07	28.57	29.17	29.90	30.70		
November	22.50	27.06	23.30	25.10	24.60	25.93	25.67	27.10		
December	17.75	21.13	18.20	20.20	19.40	21.40	19.53	21.73		

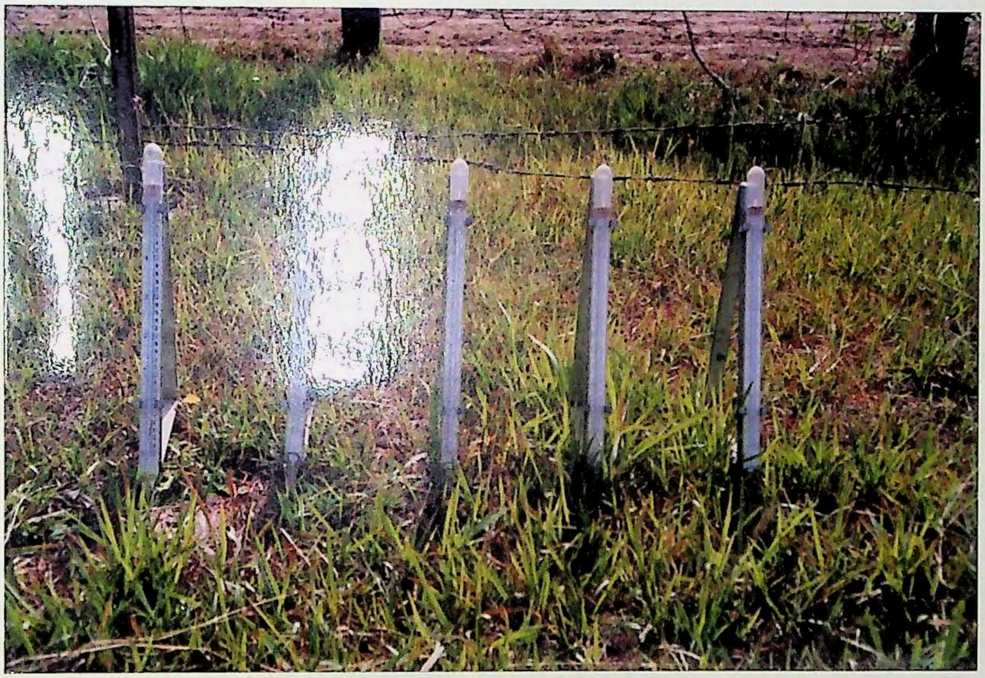


Fig-6 Photograph of Thermometers

2.8. Climatic classification:

Different combination of processes in the earth's climatic system produced many variations in climate from place to place and from time to time. An area of the earth's surface over which the combined effects result in an approximately homogeneous set of climatic conditions, that is termed as climatic region . It is common phenomenon in nature that no two places in the world have exactly the same climate, but it is possible to identify some regions in which the climates can be said to be similar. On that principle the climatic classification has been developed in 1931. The climatic classification methods are discussed below.

Koppen:

Koppen was the pioneer in the field of classification of climate. His classification is based on annual and monthly means of temperature and rainfall. Five major climate groups are designated by capital letters as follows:

A. Tropical forest climates; hot all seasons

B. Dry climates

C. Warm temperature rainy climates; mild winters

D. Cold forest climates; server winter

E. Polar climates.

De Martonne:

De Martonee has defined his aridity index as

$$I = \frac{\text{Mean Annual rainfall in mm.}}{\text{Mean Annual temperature in } ^{\circ}\text{C} + 10}$$

The different indices broadly correspond with the following vegetational zones:

Aridity Index	Vegetation
Less than 5	Desert
5-10	Dry Steppe
10-20	Prairie
20-30	Transition between grassland & forest
More than 30	Forest

2.8.1 Analysis of climatic pattern by Koppen method:

Koppen climate system, devised in 1918 by Koppen (Houghton, 1985). For several decades this system, with various later revisions, was the most widely used climatic classification among geographers. Koppen was both a climatologist and a plant geographer, so that his main interest lay in finding climate boundaries that coincided approximately with boundaries between major vegetation types.

Under the Koppen's system each climate is defined according to assigned values of temperature and rainfall computed in terms of annual or monthly values. Any given station can be assigned to its particular climatic group and subgroup solely on the basis of the records of temperature and rainfall at that place.

According to Koppen classification of climatic zone, Rajshahi City comes under the perview of Am Zone. Am implies that the Tropical monsoon: Hot, seasonally excessive rainfall.

Where, A Average temperature of coolest month 18°C or higher.

m Rainfall in driest month less than 60mm.

Here, December is the coollest month and April is the driest month.

In Table – (7), it is observed that the average temperatures of the coolest month (December) for the year from 1995 to 1998 are 19.10°C, 19.20°C, 21.60°C, 20.45°C respectively.

In Table – (6), it is observed that the rainfalls in the driest month (April) for the year from 1995 to 1999 are 18mm, 73mm, 55mm, 33mm, 9mm respectively.

2.8.2. Analysis of climatic pattern by De Martonee method:

According to De Martonee,

$$\text{Aridity index, I} = \frac{\text{Mean Annual rainfall in mm}}{\text{Mean Annual temperature in °C} + 10}$$

According to De Martonee classification, aridity indices vary from 30 to 122. The different indices broadly correspond with the following vegetational Zones:

Aridity Index	Vegetation
30 to 59	Less vegetation
60 to 99	Moderate vegetation
100 to 122	More vegetation

For the present work, 5 years (1995-1998) data for the mean annual rainfall and mean annual temperature of Rajshahi City are given.

Mean annual rainfall = 1402 mm

Mean annual temperature = 25.6°C

$\therefore$ The aridity index for Rajshahi City is, $I = \frac{1402}{25.6 + 10} = 39.38$

From this aridity index, it is observed that Rajshahi is the Less vegetation area.

Chapter - 3

Determination of Trace Elements

3.1. PIXE

In the present day world, the energy dispersive X-ray spectrometry has emerged as one of the powerful analytical methods for rapid simultaneous multi elemental analysis, either in trace or minor concentration.

The identification and the quantification of characteristic X-rays has been found as the basis of this method for qualitative and quantitative analysis respectively.

Electrons and photons (X-rays and γ-rays) have long been used to excite characteristic X-rays from target atom. Protons and other heavy ions such as alpha particles with few MeV of kinetic energy are now being widely used for this purpose, in view of the fact that such an excitation process produces relatively lower background and has large X-ray production cross-section. The method of characteristic X-ray excitation where charged particles are used is commonly referred to as Particle Induced X-ray Emission (PIXE) spectroscopy.

The development of high resolution X-ray detectors [Si(Li) and HPGE] and the availability of low energy proton accelerator has augmented the scope of PIXE which is now very much known as Proton Induced X-ray Emission spectroscopy.

In the present investigation, the PIXE method was used for the analysis of vegetables. The method was developed/adopted at the Atomic Energy Centre Laboratory, Dhaka, for performing multielement analysis down to ppm level in wide variety of practical samples.

Proton Induced X-ray Emission (PIXE) has been widely used in recent years in performing trace element analysis in environmental, biological and medical samples.

In PIXE analysis a specimen is bombarded with charged particle namely proton so that inner shell vacancies are produced in the target with the life time being of the order of 10^{-13} seconds. These vacancies are then filled up by electronic transition from higher shells resulting the emission of X-ray and also of auger electrons. The X-rays emitted in this process is characteristic of any element present in the matrix. In case of thin samples the yield of characteristic X-rays due to any element present in the specimen is determined by the X-ray production cross-section at the incident energy E_0. For uniform thin specimen, the yield Y_0 (i) of characteristic X-rays form an element "i" due to the passing of N_p number of proton is given by

$$Y(i) = N_p \in_i \frac{\Omega \, Ci \, Na}{4 \pi \, Ai \, (z)} \sigma \, (Eo) \quad \text{............... (1)}$$

Where,

$\in_i$ ⟶ efficiency of the detector at energy of X-ray for element "i"

Ω ⟶ detector solid angle

Ni ⟶ number of atoms of element "i" per gram of the matrix

Ci ⟶ concentration of element "i" in the sample

Na ⟶ Avogadro's number

A_i (Z) ⟶ atomic mass of the element "i"

σ (E_0) ⟶ X-ray production cross section at energy E_0

In case of a thick specimen the proton energy loss and attenuation of characteristic X-ray have to be taken into account. In such cases, the production of characteristic X-rays by bombardment of proton can be calculated integrating the X-ray production cross-section between the incident and exit proton energies "E_0" and "O", taking the self absorption of emitted X-rays into account. Therefore, taking account for detector efficiency, experimental geometry and energy degradation proton beam within the material the X-ray yield for a thick target is given by,

$$Y(i) = N_p \in_i \frac{\Omega}{4\pi} \int_{\in_0}^{0} \frac{C_i Na}{A_i(Z)} \exp(\mu_i x) \delta_i(E) \frac{dE}{Sm(E)} \quad \text{............(2)}$$

Where, μ_i ⟶ mass absorption coefficient of x-ray from the element "i" in the absorber,

$S_m(E)$ ⟶ stopping power of proton within the sample matrix,

E ⟶ instantaneous energy of proton in the sample,

X ⟶ depth within the matrix at which the protons have degraded from incident energy E_o to energy E.

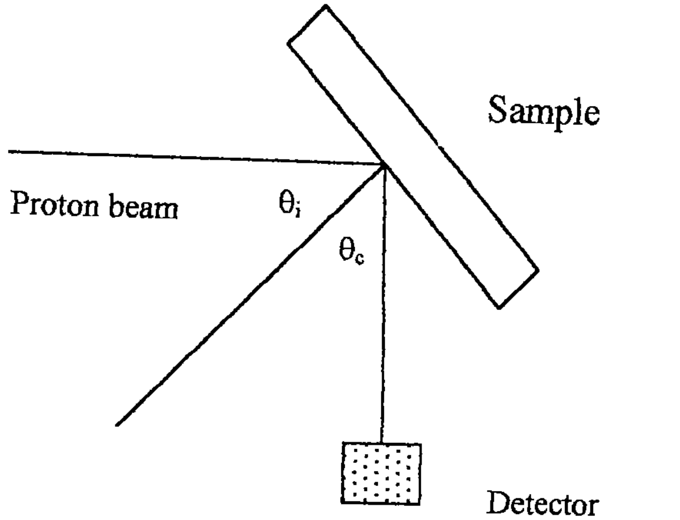


Fig.7. Path of P-beam & X-ray

The thickness x is given by,

$$X = \int_{E_0}^{E} \frac{dE}{Sm(E)} \frac{Cos\theta_i}{Cos\theta_c}$$

θ_i ⟶ angle between the beam and an axis perpendicular to larget surface.

θ_c ⟶ emergence angle of the X-ray with respect to target.

For absolute measurement of concentration numerical solution of equ^n (2) has to be obtained.

3.2. ADVANTAGES:

Of the known methods of air particulate analysis such as AAS, XRF, NAA, PIXE, etc. the particle-induced X-ray emission (PIXE) method offers some convenience as a large throughout multielement analytical capablitity. It is interesting to note that the application of PIXE to atmospheric research makes use of all its advatageous features. The high absolute sensitivity makes it possible to perform a multi-elemental analysis of samples with a very low massloadin. Concerning sensitivity, PIXE is considerable better than flame AAS and ICP . Hence, one can use many size classes in the sampling and/or good time resolution. This in turn leads to a great number of samples and consequently a fast analytical method is needed; the high speed of PIXE is therefore a prerequiste. In PIXE the minimum detectable amount is $10^{-15} - 10^{-16}$g. With a millimeter sized beam one can achieve absolute detection limits in the picogram range.

PIXE in principle, a better method, it is more complete and versatile. It is highly automated and easy to operate and has an excellent accuracy and precision.

As a comparison with other analytical methods, it is fair to say that PIXE is a very complete method. No other method can show such a combination of sensitivity, speed and multi-elemental capability.

3.3. LIMITATIONS:

In view of this positive picture there must obviously be some limitations that prevent PIXE from being more widely used. The main problem is, of course, the necessity of having access to an accelerator. This might create the impression that PIXE is an expensive method, which, however, is not the case. The reason is the high spped of PIXE analysis. An automated system can easily handle analysis of the order of 100 per hour. The cost of beam time is more difficult to estimate since it depends on the type of accelerator, laboratory organization, etc.

One of the limitations of PIXE is that the light elements (Z< 19 in the present case) cannot be determined. This is especially serious in air pollution research since light elements (C, S, Al, Si, etc), are considered as important pollutants in aerosol and these determine to a great extent its properties and impact on the environment. One possible way of determining the light elements is to combine PIXE with other nuclear methods.

3.4. INSTRUMENTATION IN PIXE:

The basic components of the experimental setup for the external beam PIXE used in the present work is shown in Fig-(8). The proton beams of 2.5 Mev energy are obtained from the 3 Mev Van de Graaff aecelerator at the atomic Energy Centre, Dhaka (AECD). Two collimators of 2mm diameter each and a 4mm cleanup aperture, all made of tantalum are used to obtain finely collimated beam. Kapton foils of 1.12 mg/cm^2 thickness are used to extract proton beams into the air.

The energy of the proton beam on the target is about 2 Mev after energy loss in the kapton foil and air between the exit window and the sample. To intergarate the proton charge bombarding the sample, total current on the target and the kapton window is monitored. The window frame is insulated form the beam port and the collimator. This arrangement is very repoducible for measurment of total charge on the target. The samples on solid frames are positioned at 45° with respect to the beam direction and the characteristic X-rays are detected at 90° with respect to the beam, a plastic absorber is used to reduce the argon background present in the atmospheric air where targets are bombarded.

The X-ray data collection and processing system consists of 30mm^2 ORTEC Si (Li) detector having the resolution (full width at half maxima) of

170 ev at 5.9 kev pre amplifier, main amplifier, a 1024 channel multichannel analyzer (MCA) in pulse height analysis (PHA) mode and an IBM compatible 486 computer.

3.5 COLLECTION AND PREPARATION OF VEGETABLE SAMPLES:

All available types of vegetables were collected from the local markets under the Municipal Corporation of Rajshahi district. These vegetables were of winter season variety. These were Potato, Radish, Gourd, Cabbage, Cauliflower, Bean, Carrot, Brinjal, Celery, Palk.

The sampleswere first cleaned. Then these were cut into pieces and were allowed to dry under direct sun and humidity condition for 3 days. Then in order to reduce more water content, the samples were kept into oven at 50°C for 48 hours. Then the samples were powdered and pellets of about 100 mg wt, 12mm in diameter and 1mm thickness, were formed with a graduated stainless steel pellet maker under 15000 psi pressure.

3.6. SAMPLE IRRADIATION:

Vegetable pellets mounted on slide frame have been irradiated in the externeal beam of PIXE set-up of the Van de Graafff accelerator at AECD, placing their smooth surface inclined at 45° to the beam dirrection as shown in Fig.7. The beam current is maintained at 10 nA and each sample is irradiated with a total charge of approximately 10 μC The energy of proton beam after energy loss at the exit window and the air path is about 2.0 MeV.

3.7. DATA ANALYSIS:

The analytical information on the presence and concentrations of each of the elements present in a sample is confined in a spectrum of characteristic X-ray peaks sitting on an energy dependent continuum. The general features of an X-ray spectrum include the following:

- a broad and smoothly varying background, i.e., the continum which come from projectile Bremstrahlung and secondary electron Bremstrahlung.
- multiple characteristic X-ray linesidentifyingelements present in the sample.
- interference between X-ray lines of different elements.

The ideal spectrum consists of Gaussian peaks sitting on a continuum background. But in practice, spectral analysis is complicated by the presence of sum and escape peaks distortion in the Gaussian shape and interference between the characeristic peaks of different elements in the sample.

A computer code AXIL (Analysis of X-ray Spectra by Iterative Least square fitting) developed by Van Espen was used for unfolding all the PIXE spectra. Numerical correction method for accurate peak shape description is incorporated into the interactive non-linear least squares fitting procedure. The program can deconvolute overlaying peaks, sum and escape peaks by optimizing all the parameters present in the fitting model. The required parameters are the background parameters, calibration parameters, experimental condition and the matrix description.

An X-ray library consists of the characteristic X-ray energies and the relative intensity ratios of all the elements are incorporated into this program.

A Lithium drifted silican crystal [Si (Li)] is used to detect characteristic X-rays produced from the sample. Such a detector of 30 mm^2 area has a resolution of 170 eV at 5.9 KeV energy region. The data acquisition system includes a pre-amplifier, main amplifier, a 1024 channel Multichannel Analyzer (MCA) in pulse height analysis (PHA) mode, and an IBM compatible 486 computer.

In the present work, the collected data for trace elements for different winter vegetables are shown in Table-(15-24).

The schematic diagram of PIXE method is shown in Fig-(8)

A typical characteristic X-ray spectrum of vegetable sample No. PX 4150 is shown in Fig- (9).

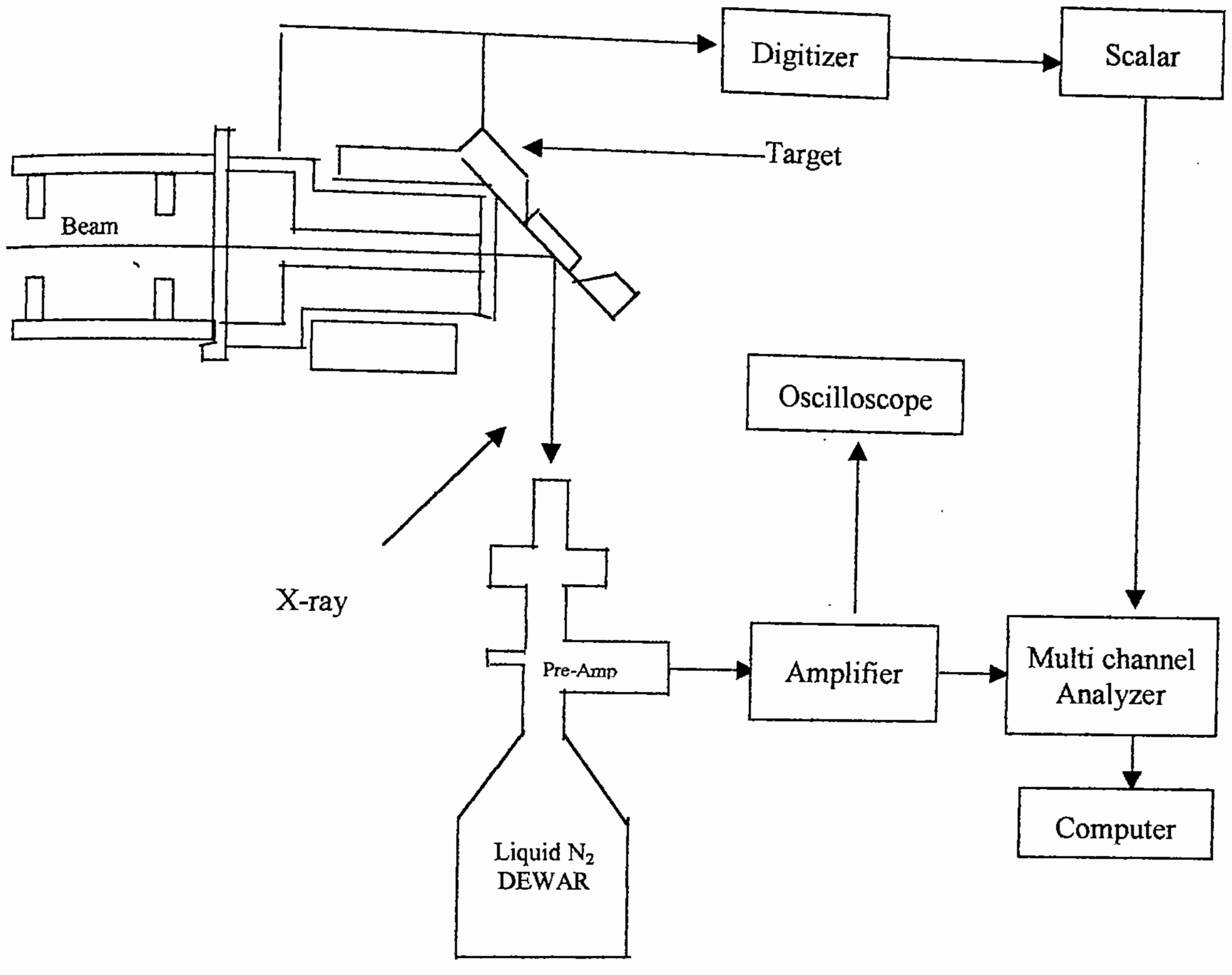


Fig-8: Schematic diagram of PIXE setup

Table-15 : PIXE results for Potato

Z-number	Elements	Concentration µg/g	Error
19	K	8115.24	34.00
20	Ca	661.31	7.88
22	Ti	26.11	0.97
24	Cr	2.81	0.36
25	Mn	8.57	0.38
26	Fe	311.19	1.54
27	Co	1.38	0.41
28	Ni	48.96	0.71
29	Cu	4.39	0.31
30	Zn	12.10	0.48
31	Ga	0.42	0.25
32	Ge	0.47	0.30
35	Br	2.86	0.70
37	Rb	13.42	1.62
38	Sr	4.36	1.62
40	Zr	1.07	3.20
82	Pb	2.78	1.39

Table-16 : PIXE results for Radish

Z-number	Elements	Concentration µg/g	Error
19	K	19796.53	27.05
20	Ca	4069.20	7.95
22	Ti	20.63	0.46
24	Cr	0.84	0.19
25	Mn	14.14	0.23
26	Fe	467.48	0.97
27	Co	1.95	0.25
28	Ni	4.25	0.16
29	Cu	3.03	0.16
30	Zn	16.14	0.30
31	Ga	0.48	0.16
32	Ge	0.71	0.17
35	Br	4.98	0.38
37	Rb	17.27	0.87
38	Sr	20.44	0.97
40	Zr	4.29	1.07
82	Pb	4.41	0.42

Table-17 : PIXE results for Gourd

Z-number	Elements	Concentration µg/g	Error
19	K	17501.15	61.47
20	Ca	2290.50	15.97
22	Ti	33.92	1.34
24	Cr	0.80	0.45
25	Mn	12.54	0.55
26	Fe	269.03	1.78
27	Co	0.49	0.49
28	Ni	4.52	0.40
29	Cu	8.60	0.51
30	Zn	14.65	0.67
32	Ge	0.58	0.41
33	As	0.22	0.60
35	Br	1.62	0.86
37	Rb	44.94	2.96
38	Sr	4.13	1.94
40	Zr	1.07	3.75

Table-18 : PIXE results for Cabbage:

Z-number	Elements	Concentration µg/g	Error
19	K	16019.91	19.31
20	Ca	6092.02	7.22
22	Ti	26.38	0.36
24	Cr	1.69	0.15
25	Mn	25.38	0.22
26	Fe	245.36	0.56
27	Co	0.83	0.16
28	Ni	6.47	0.14
29	Cu	0.74	0.12
30	Zn	16.32	0.22
35	Br	1.43	0.19
37	Rb	59.28	1.05
38	Sr	15.32	0.73
42	Mo	10.94	3.13
82	Pb	6.92	0.42

Table-19 : PIXE results for Cauliflower:

Z-number	Elements	Concentration µg/g	Error
19	K	18178.84	20.05
20	Ca	4420.82	6.38
22	Ti	24.44	0.36
24	Cr	0.84	0.13
25	Mn	18.52	0.20
26	Fe	270.61	0.58
27	Co	1.53	0.16
28	Ni	9.80	0.16
29	Cu	2.75	0.14
30	Zn	39.20	0.32
37	Rb	98.01	1.39
38	Sr	12.62	0.73
42	Mo	7.80	3.12

Table-20 : PIXE results for Bean:

Z-number	Elements	Concentration µg/g	Error
19	K	11930.53	53.47
20	Ca	5585.37	22.44
22	Ti	54.88	1.58
24	Cr	1.14	0.48
25	Mn	41.48	0.83
26	Fe	536.58	2.50
27	Co	3.35	0.65
28	Ni	15.83	0.59
29	Cu	8.79	0.51
30	Zn	26.83	0.86
31	Ga	0.86	0.38
32	Ge	0.46	0.46
37	Rb	42.13	2.96
38	Sr	13.35	2.67
40	Zr	0.54	3.75
42	Mo	10.93	10.93
82	Pb	3.98	2.09

Table-21: PIXE results for Carrot:

Z-number	Elements	Concentration µg/g	Error
19	K	12995.79	17.48
20	Ca	4650.37	6.38
22	Ti	98.86	0.57
24	Cr	1.37	0.15
25	Mn	29.20	0.23
26	Fe	886.35	1.03
27	Co	1.38	0.23
28	Ni	37.18	0.26
29	Cu	7.50	0.16
30	Zn	24.65	0.27
32	Ge	0.46	0.12
35	Br	0.67	0.19
37	Rb	27.85	0.87
38	Sr	11.65	0.73
82	Pb	10.05	0.42

Table-22 : PIXE results for Brinjal:

Z-number	Elements	Concentration µg/g	Error
19	K	15155.48	18.52
20	Ca	4507.99	6.30
22	Ti	19.74	0.34
24	Cr	0.56	0.13
25	Mn	10.52	0.17
26	Fe	417.49	0.72
27	Co	0.45	0.18
28	Ni	2.51.	0.11
29	Cu	5.37	0.14
30	Zn	20.11	0.25
35	Br	0.48	0.19
37	Rb	59.40	1.05
38	Sr	13.36	0.73
40	Zr	6.96	1.07
42	Mo	3.12	3.12
82	Pb	3.56	0.42

Table-23 : PIXE results for Celery (Lal Shak):

Z-number	Elements	Concentration µg/g	Error
19	K	19367.36	68.43
20	Ca	17619.14	37.02
22	Ti	101.32	1.95
24	Cr	0.12	0.57
25	Mn	41.09	0.88
26	Fe	820.89	3.07
27	Co	5.92	0.85
28	Ni	62.10	1.06
29	Cu	11.51	0.65
30	Zn	82.23	1.46
31	Ga	0.45	0.51
32	Ge	3.91	0.71
33	As	0.22	0.88
35	Br	1.92	1.06
37	Rb	89.89	4.20
38	Sr	54.63	4.15
42	Mo	12.54	12.54
82	Pb	6.73	2.31

Table-24: PIXE results for Palk (Palong Shak):

Z-number	Elements	Concentration μg/g	Error
19	K	18163.48	102.81
20	Ca	8873.71	43.40
22	Ti	244.03	4.18
24	Cr	3.94	1.04
25	Mn	69.22	1.76
26	Fe	1919.48	7.40
27	Co	0.76	1.76
28	Ni	69.54	1.82
29	Cu	9.54	1.14
30	Zn	31.83	1.69
31	Ga	1.77	1.13
32	Ge	7.13	1.47
35	Br	7.97	2.42
37	Rb	52.88	5.73
38	Sr	28.88	5.53
42	Zr	19.75	19.75
82	Pb	25.44	5.30

Chapter-4

Results and Discussions

In our present work, month wise and yearly observations for different environmental parameters (Humidity, Rainfall, Temperature, Sunshine hour, Wind speed, Dew temperature and Soil temperature) of Rajshahi City were measured. Also trace elements in different winter variety vegetables collected from Rajshahi City market were measured by PIXE method. The respective findings are given below:

Climatologically, Bangladesh is a very interesting country of Asia, because the monsoon brings heavy and torrential rainfall with appreciable variations from year to year and striking differences from place to place. In Bangladesh the meteorologists divided the year into the following four principal seasons:

1. The Cold Weather Season - December to February.
2. The Hot Weather Season - March to May.
3. The Southwest Monsoon Season - June to September.
4. The Post Monsoon Season - October to November.

Humidity

Monthwise humidity was observed to attain the values from 41% to 98% in the year between 1995-1999. 41% humidity was found in the month February, 1999 and 98% was found in December, 1997 [Table - 5].

Seasonal distribution of Humidity:

1. The Cold Weather Season : During this season the humidity of Rajshahi varies from 41% to 98%. The whole country experiences above 70% humidity during this season [R-35].
2. The Hot Weather Seasons: In this season the humidity of Rajshahi varies from 48% to 93%. During this season, the humidity varies form 61% at Dinajpur to 82% at Bhola [R-36].
3. The Southwest Monsoon Season: Monsoon is the season, when the percentage of humidity occurs high due to the damp conditions. During this season, the humidity varies form 64% to 97%. During this season, the humidity varies between 84% at Dinajpur and 90% at Bhola [R-35].
4. The Post Monsoon Season: In this season the humidity varies from 70% to 93%. During this season, the humidity varies from 75% at Madaripur to 85% at Bhola and Srimangal [R-35].

Rainfall:

Monthwise rainfall was found to occur from 3mm to 765 mm. The lowest level of rainfall 03mm occurred in October 1997 and the highest one 765 mm was found in July 1997 [Table-6].

Seasonal Rainfall conditions:

1. The Cold Weather Season: During this season the amount of rainfall is comparatively low out of total annual rainfall. At Rajshahi the maximum rainfall was 32mm and the minimum was 04mm. The maximum rainfall of 68mm and the minimum rainfall of 10 mm are received by Bhola and Khepupara and Sylhet respectively [R-37].
2. The Hot Weather Season: The maximum and minimum amount of rainfall was 144mm and 04mm respectively during this season at Rajshahi.

   The maximum amount of rainfall 940 mm is recorded at Sylhet and the minimum 400mm is recorded in the north-eastern part of the country[R-38].
3. The Southwest Monsoon Season: The amount of rainfall was comparatively high during this season. The maximum amount of rainfall was 765mm and the minimum was 92mm at Rajshahi. The maximum amount of rainfall of 3659mm is recorded at Teknaf and the minimum amount of 1065mm is recorded at Jessore[R-39].
4. The Post Monsoon Season: During this season the highest rainfall was 198mm and the lowest rainfall was 03mm at Rajshahi. The highest rainfall of 352mm is received by Cox's Bazar and the lowest rainfall of 116mm is received by Dinajpur during this season[R-37].

Temperature:

Temperature was seen to vary in between 4.7°C to 43.3°C. The minimum temperature 4.7°C was found in January 1995 and the maximum temperature. 43.3°C was found in May 1995 [Table - (8) and (9)].

Seasonal Temperature Conditions:

1. The Cold Weather Season: In this season the maximum and the minimum temperatureswere 30.16°C and 4.7°C respectively. During this season, the highest and the lowest maximum temperature are recorded at Teknaf and Chandpur respectively. And the highest and the lowest minimum temperature are recorded at Hatia and Ishurdi [R-40].
2. The Hot Weather Season: During this season the temperature of Rajshahi varies from 11.5°C to 43.3°C. In this season, the highest and the lowest maximum temperature are recorded at Rajshahi and Sylhet respectively. And the highest and the lowest minimum temperature are recorded at Satkhira and Rangpur respectively[R-40].
3. The southwest Monsoon Season: In this season the maximum and the minimum temperature were 38.6°C and 22.8°C respectively. During this season, the maximum temperature range from 29.4°C to 32°C. The temperature decreases from west to east of the country. The minimum temperature over the country, which is almost uniform [R-41].
4. The Post Monsoon Season: During this season the maximum and the minimum temperature were 34.6°C and 10.5°C respectively. In this season, the maximum temperature is approximately even over the country. The temperature decreases from south to north. The minimum

temperature is uneven throughout the country. The temp. increases from north to south of the country[R-42]. In this present work the lowest temperature values of the year are observed in January when the sun is overhead over the Tropic of Capricorn in the South. After January, the temperature values start increasing progressively, due to the shifting of the sun towards the north. In fact, this condition should continue upto June because the sun is overhead on 21st June over the Tropic of Cancer. The maximum temperature values tend to decrease in June, while the minimum temperature values tend to increase in the same manner. In August, the temperature values are nearly equal to those of June and July. The maximum and minimum temperature values are much reduced. Due to heavy rainfall and higher humidity, the maximum temperature does not rise rapidly, Similarly, the cloud cover does not allow the mean temperature to decrease. The temperature values decrease rapidly till January after September.

Bright Sunshine Hour:

Bright sunshine hour was observed to attain the values from 3.53h to 9.77h. The value 3.53h was found in the month July, 1995 and 9.77h was found in the month March, 1999.[Table-10].

Although April and May are the warmest months in Bangladesh, they are not the months with the most bright sunshine. There is no particular month during which the most bight sunshine occurs. The greatest number of bright sunshine hours occurs in March in Rajshahi. In the coastal areas of Chittagong, Cox's Bazar and Sylhet, the greatest number of bright sunshine hours occurs in February, in the Comilla area, in January, at Jessore February, March and April have the most[R-43].

Wind Speed:

Wind speed was under the range of values 1.6nm to 6.83nm. The minimum speed 1.6nm was observed in December 1995 and the maximum speed 6.83nm was found in June 1996 [Table-11].

The wind velocity in the month of January varies from 2.3nm at Rangamati to 5.3nm at Cox's Bazar.

In January, the wind velocity above 4nm is experienced in Chittagong, Comilla, Cox's Bazar, Hatiya, Ishurdi, Jessore and Teknaf districts.

In May, the wind velocity of above 7nm is recorded at Chittagong, Cox's Bazar and Ishurdi, whereas, the wind velocity below 4nm is recorded at Bhola, Bogra, Dinajpur, Madaripur.

In July, the wind velocity varies between 2.9nm at Madaripur and 9.5nm at Chittagong.

In November, the wind velocity is considerably low and varies from 2.2nm to 6.3 nm. The wind velocity of above 4.0nm is recorded in the districts of Chittagong, Cox's Bazar, Ishurdi and Jessore[R-44].

Dew Temperature:

Dew temperature was found to have the range 12.24°C to 27.74°C. The minimum temperature 12.24°C was found in January 1995 and the maximum temperature 27.74°c was observed in June 1998[Table-13].

Soil Temperature:

Soil temperature was seen to vary in between 16.23°C to 33°c. The minimum temperature 16.23°C was found in January, 1997 at depth of 10cm and the maximum temperature 33°C was found in May, 1995 at depth of 30cm[Table-14].

Trace Elements:

Trace elements in vegetable samples were measured by PIXE technique. The sample wise results are given below:

Potato:

In the sample of potato, different elements are present in different concentrations (shown in Table-15). Among the elements ^{19}K has the highest concentration of 8115.24 ± 34.00 μg/g and ^{31}Ga the lowest concentration 0.42 ± 0.25 μg/g.

In Table -25, we have compared only the value of Pb, Cu and Zn. We observe that the value of Pb of our work is twice that of Khan *et.al* [R-19]. Their value for Cu is two times greater than the value of our work and the value of Zn is little more than our result.

Radish:

In the sample of radish different elements present in different concentrations are shown in Table-(16). Among the elements ^{19}K has the highest concentration of 19796.53 ± 27.05 μg/g and ^{31}Ga the lowest concentration 0.48 ± 0.16 μg/g.

In Table-25, we can observe that the concentrations of Pb, Cu, Zn, Ca, Mn and Ni of Khan et.al. [R-19] are almost comparable to our results. But the concentrations of K and Fe of Khan et. al [R-19] are much lower than the concentrations of present work.

Gourd:

In the sample of gourd, different elements present in different concentrations are shown in Table-(17). Among the elements ^{19}K has the highest concentration of 17501.15 ± 61.47 μg/g and ^{33}As the lowest concentration 0.22 ± 0.60 μg/g.

In Table-25, we observe that the concentrations of Cu, Zn, Ca, Cr of Khan et.al [R-19] are almost identical to our results. Their value of Mn is four times greater than our result and the value of Ni is two times greater than our result. Their values of K and Fe are much lower than our values.

Cabbage:

In the sample of cabbage, different elements present in different concentrations (shown in Table-18). Among the elements ^{19}K has the highest concentration of 16019.91 ± 19.31 μg/g and ^{29}Cu the lowest concentration 0.74 ± 0.12 μg/g.

In Table-25, we can see that the value of Pb and Mn of our work are twice of Khan et.al [R-19]. Their value of Cu is six times greater and Zn is two times greater than our value. Our value of Ni is ten times greater than Khan et.al [R-19]. Their vlaue of Ca is almost same as ours.

Cauliflower:

In the sample of cauliflower, different elements present in different concentrations (shown in Table-19). Among the elements ^{19}K has the highest concentration of 18178.84 ± 20.05 μg/g and ^{24}Cr the lowest concentration 0.84± 0.13 μg/g.

In Table-25, we can find that our values of Zn, Ca, Mn and Ni are almost same with Khan et.al [R-19]. Their value of Cu is twice of our value and the values of K and Fe are much lower than our results.

Bean:

In the sample of bean, different elements present in different concentrations (shown in Table-20). Among the elements ^{19}K has the highest concentration of 11930.53 ± 53.47 μg/g and ^{32}Ge the lowest concentration 0.46 ± 0.46 μg/g.

In Table-25, we can observe that the concentrations of Pb, Cu, Zn, Ca of Khan et.al [R-19] are almost same as our values but the values of K and Fe are much lower than our values. Our value of Mn is two times greater than that Khan et.al [R-19]. And the value of Ni is little more than twice of our result.

Carrot:

In the sample of carrot, different elements present in different concentration (shown in Table-21). Among the elements ^{19}K has the highest concentration of 12995.790.46 ± 17.48 μg/g and ^{32}Ge the lowest concentration 0.46 ± 0.12 μg/g.

We can not make any comparison due to non availability of data.

Brinjal:

In the sample of brinjal, different elements present in different concentrations (shown in Table-22). Among the elements ^{19}K has the highest concentration of 15155.48 ± 18.52 μg/g and ^{27}Co the lowest concentration 0.45± 0.18 μg/g.

In Table-25, we observe that the values of Pb, Zn, Ca, Mn, Ni of Khan et.al[R-19] are almost same as ours and the value of Cu is two times greater than our result. But the values of K and Fe of Khan et.al [R-19] are much lower than those of our values.

Celery:

In the sample of celery, different elements present in different concentrations (shown in Table-23). Among the elements ^{19}K has the highest concentration of 19367.36 ± 68.43 μg/g and ^{24}Cr the lowest concentration 0.12 ± 0.57 μg/g.

In Table-25, we have compared only the values of Pb, Cu and Zn. We see that the value of Pb of Khan et.al [R-19] is almost same as ours but the value of Cu and Zn are almost two times greater than our values.

Palk:

In the sample of palk, different elements present in different concentrations (shown in Table-24). Among the elements ^{19}K has the highest concentration of 18163.48 ± 102.81μg/g and ^{27}Co the lowest concentration 0.76 ± 1.17 μg/g.

In Table-25, we can compare only the concentrations of Pb, Cu and Zn. We observe that the value of Pb of our work is six times greater than of Khan et.al [R-19]. Their value of Cu is three times greater than our result and the value of Zn is twice of our value.

Finally, our results are compared with those found by others and are shown in Table-(25).

Table-25: Comparison of our PIXE results with others
(Concentration in μg/g)

Name of the vegetables	Pb	Cu	Zn	K	Ca	Cr	Mn	Fe	Ni	Refference
Potato	2.78	4.39	12.10	8115.24	661	2.81	8.57	311.19	48.96	Present work
	1.25	8.07	16.30	-	-	-	-	-	-	R-19
Radish	4.41	3.03	16.14	19796.53	4069	0.84	14.14	467.48	4.25	P.W
	3.18	4.73	25.80	144	3665	-	7.59	17.20	2.62	R-19
Gourd	-	8.60	14.65	17501.15	2290	0.80	12.54	269.03	4.52	P.W
	-	6.20	22.70	159	3527	1.48	51.2	30.50	8.78	R-19
Cabbage	6.92	0.74	16.32	16019.91	6092	1.69	25.38	245.36	6.47	P.W
	3.63	4.55	29.70	140	6142	-	12.40	25.10	0.62	R-19
Cauliflower	-	2.75	39.20	18178.84	4420	0.84	18.52	270.61	9.80	P.W
	1.81	5.22	37.76	189	3172	-	19.30	61.80	6.39	R-19
Bean	3.98	8.79	26.83	11930	5585	1.14	41.48	536.58	15.83	P.W
	2.95	11.27	31.30	207	4360	-	21.50	61.90	3.65	R-19
Carrot	10.05	7.50	24.65	12995.79	4650	1.37	29.20	886.35	37.18	P.W
	-	-	-	-	-	-	-	-	-	R-19
Brinjal	3.56	5.37	20.11	1515.48	4507	0.56	10.52	417.49	2.51	P.W
	2.04	11.96	15.09	236	4259	-	8.93	29.10	2.67	R-19
Celery	6.73	11.51	82.23	19367.36	17619.14	0.12	41.09	820.89	62.10	P.W
	7.73	19.2	172.02	-	-	-	-	-	-	R-19
Palk	25.44	9.54	31.83	18163.48	8873.71	3.96	69.22	1919.48	69.54	P.W
	4.58	26.13	67.60	-		-	-	-	-	R-19

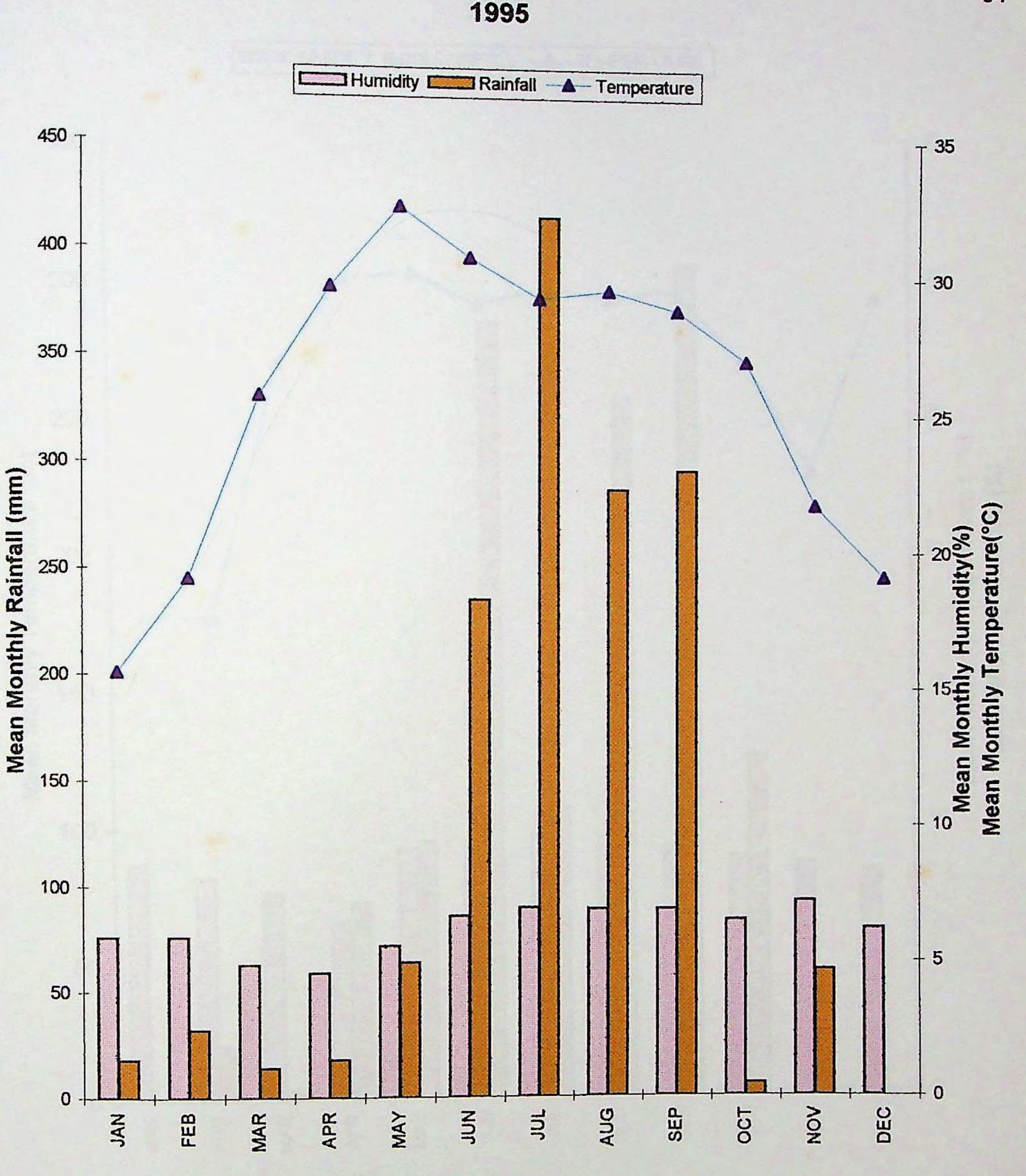


Fig.10 Climatic Diagram For Rajshahi

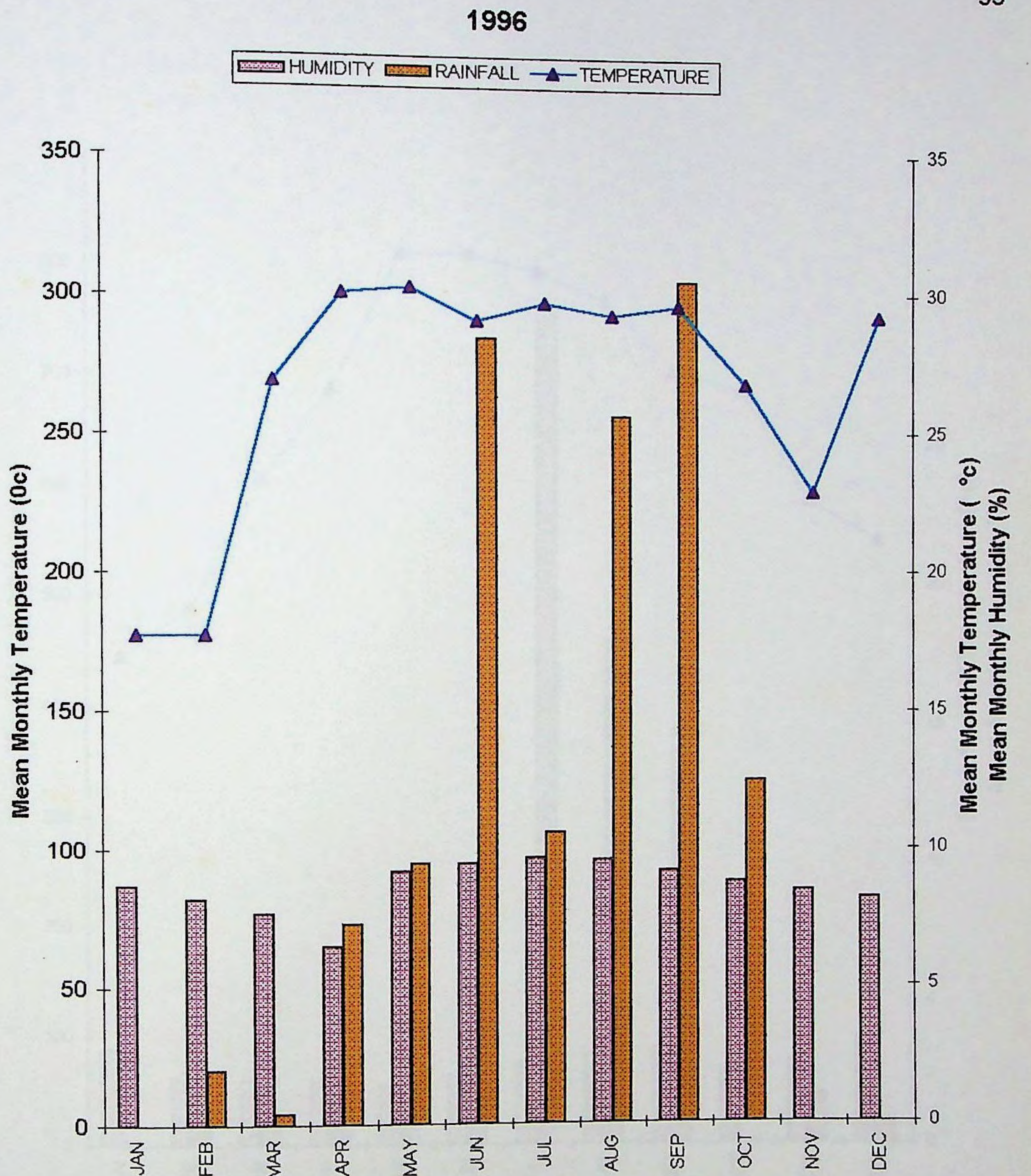


Fig.11 Climatic Diagram for Rajshahi

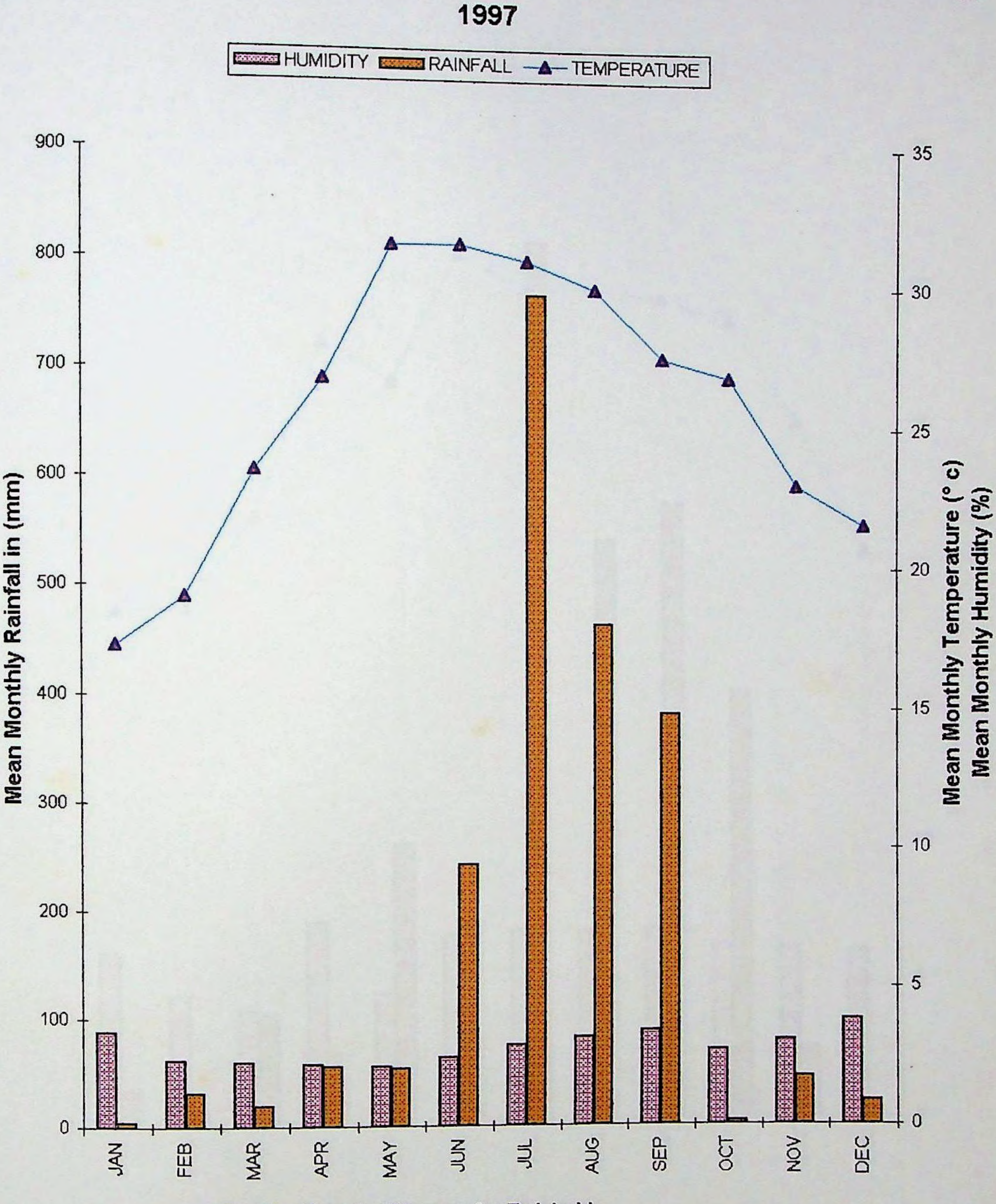


Fig.12 Climatic Diagram for Rajshahi

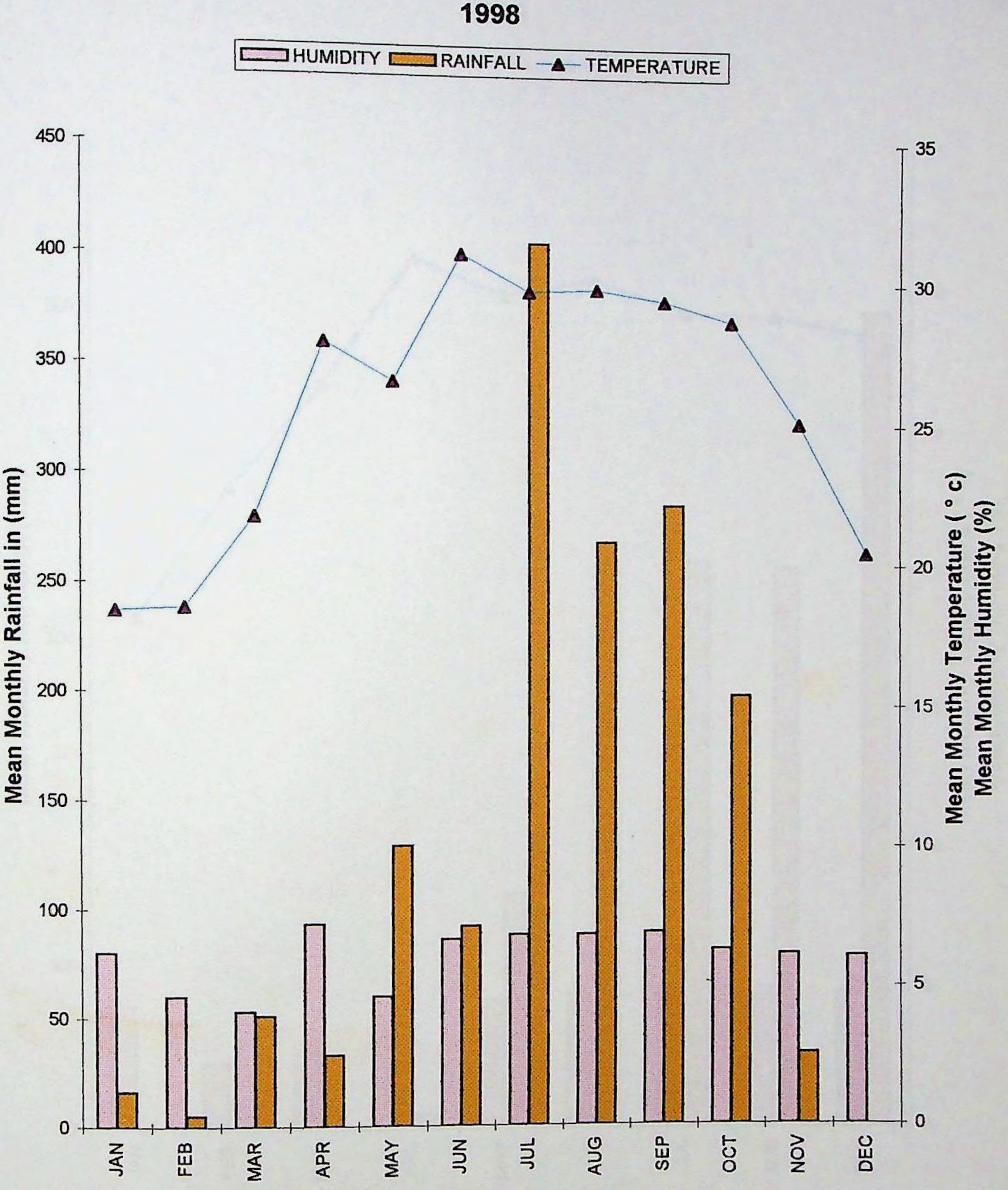


Fig.13 Climatic Diagram for Rajshahi

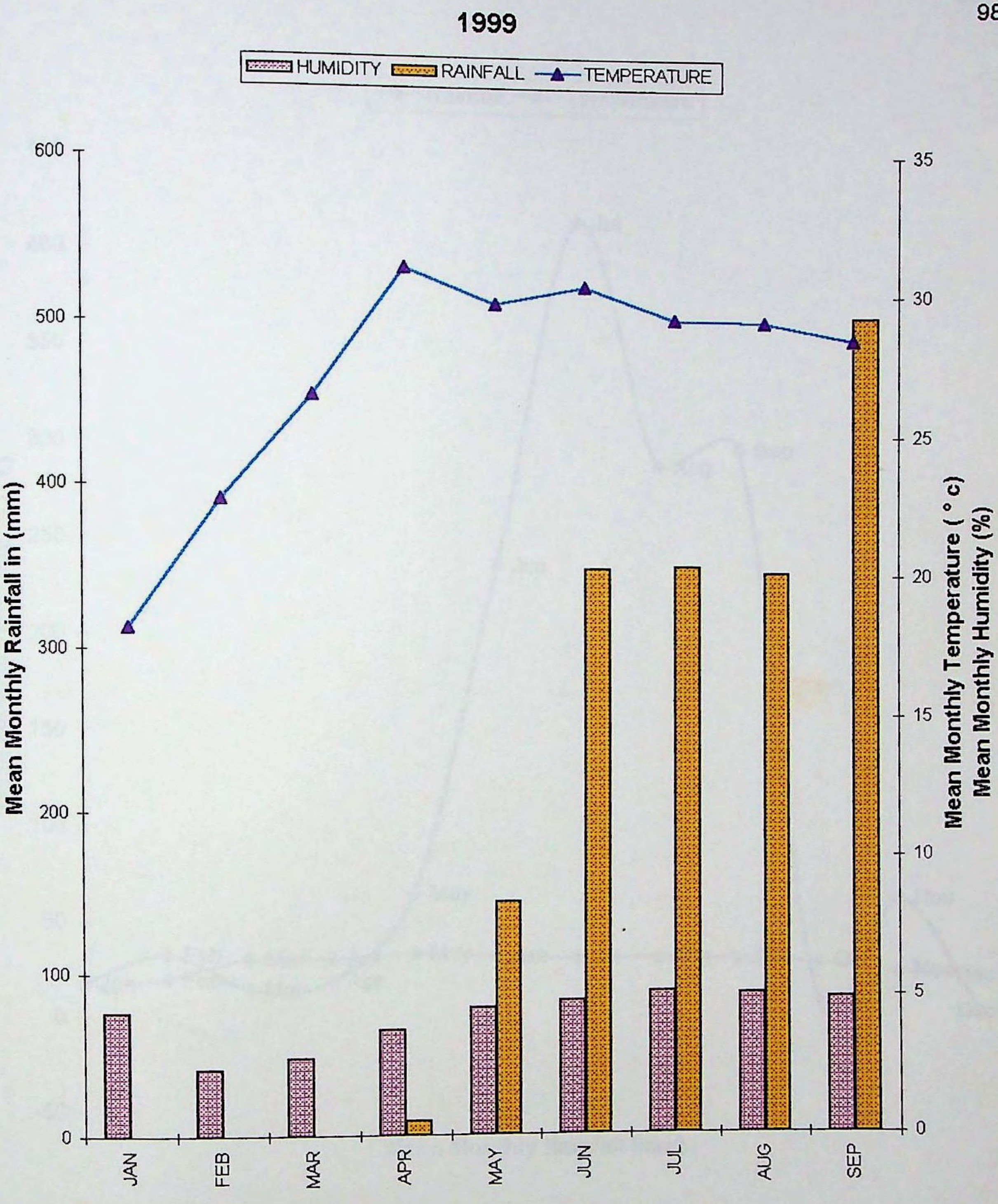


Fig.14 Climatic Diagram for Rajshahi

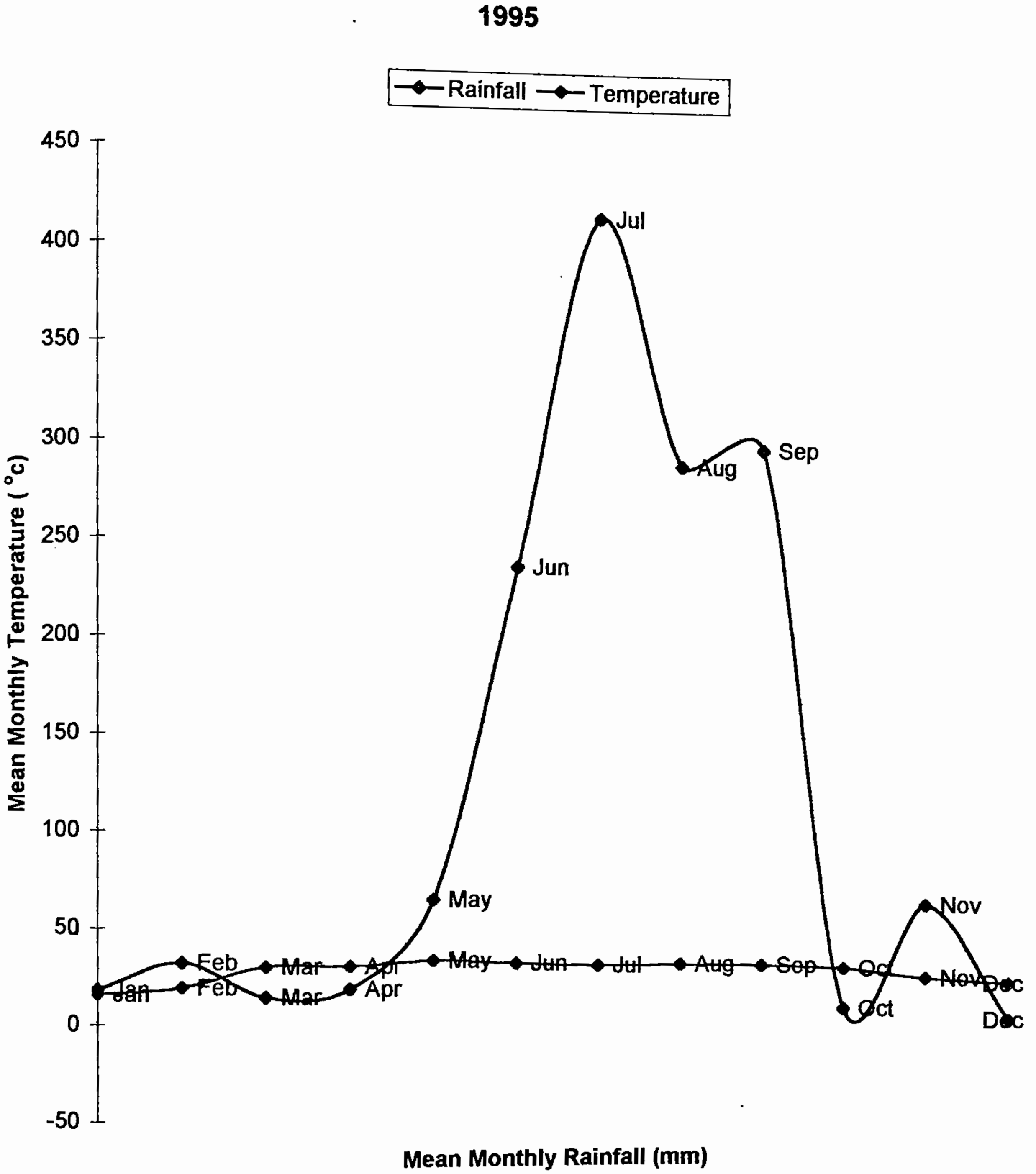


Fig.15 Hythergraph for Rajshahi

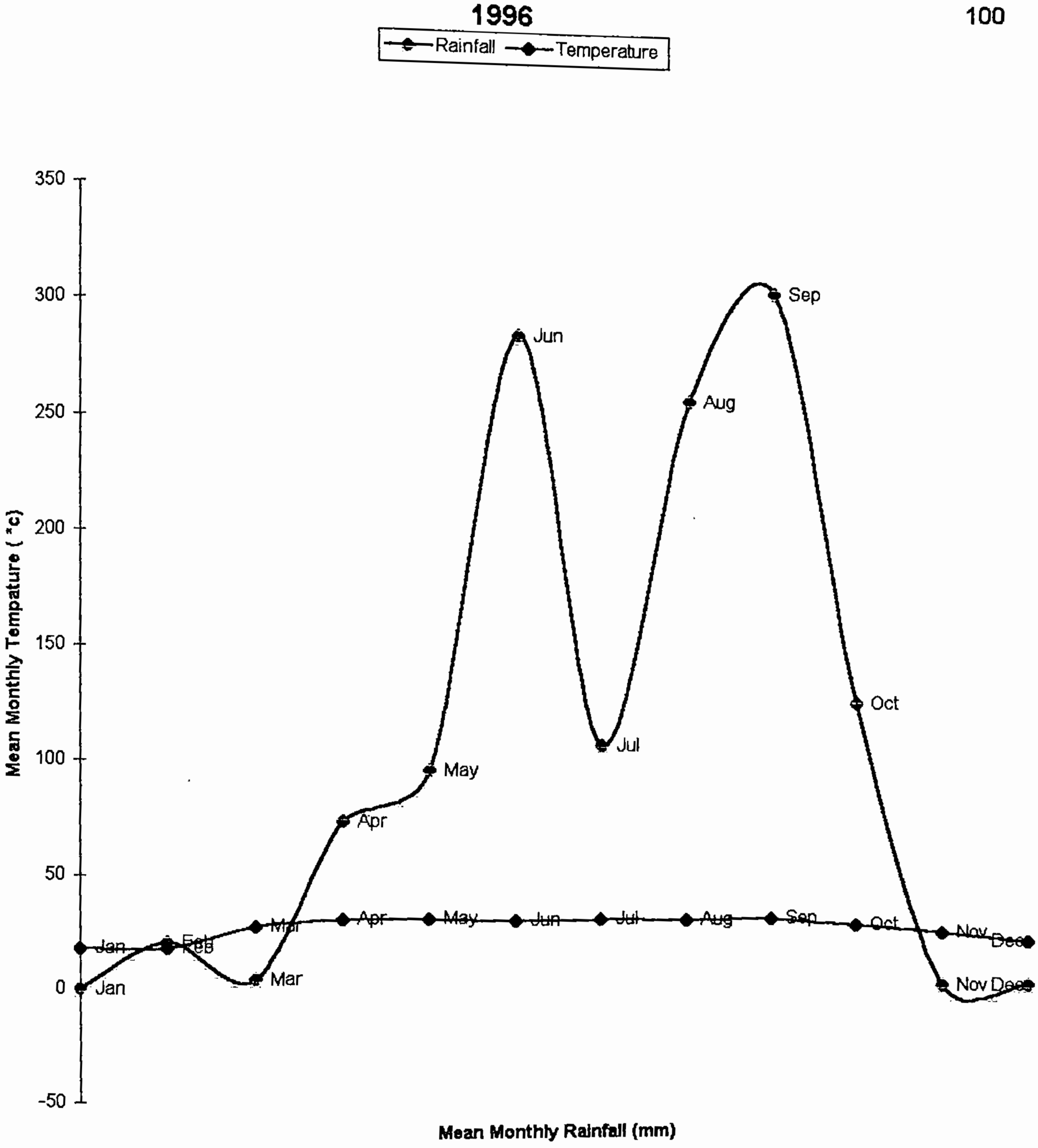


Fig.16 Hythergraph for Rajshahi

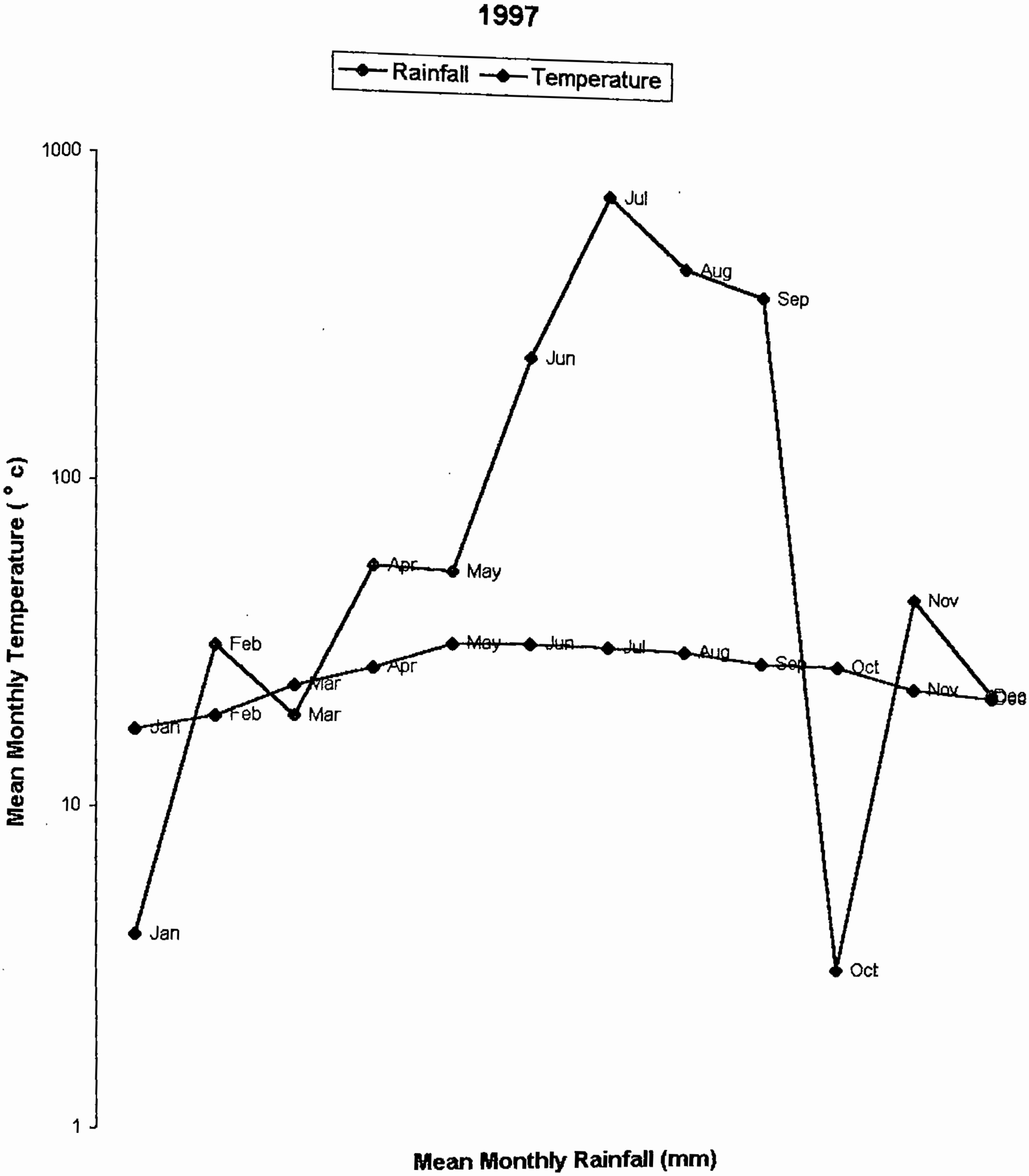


Fig.17 Hythergraph for Rajshahi

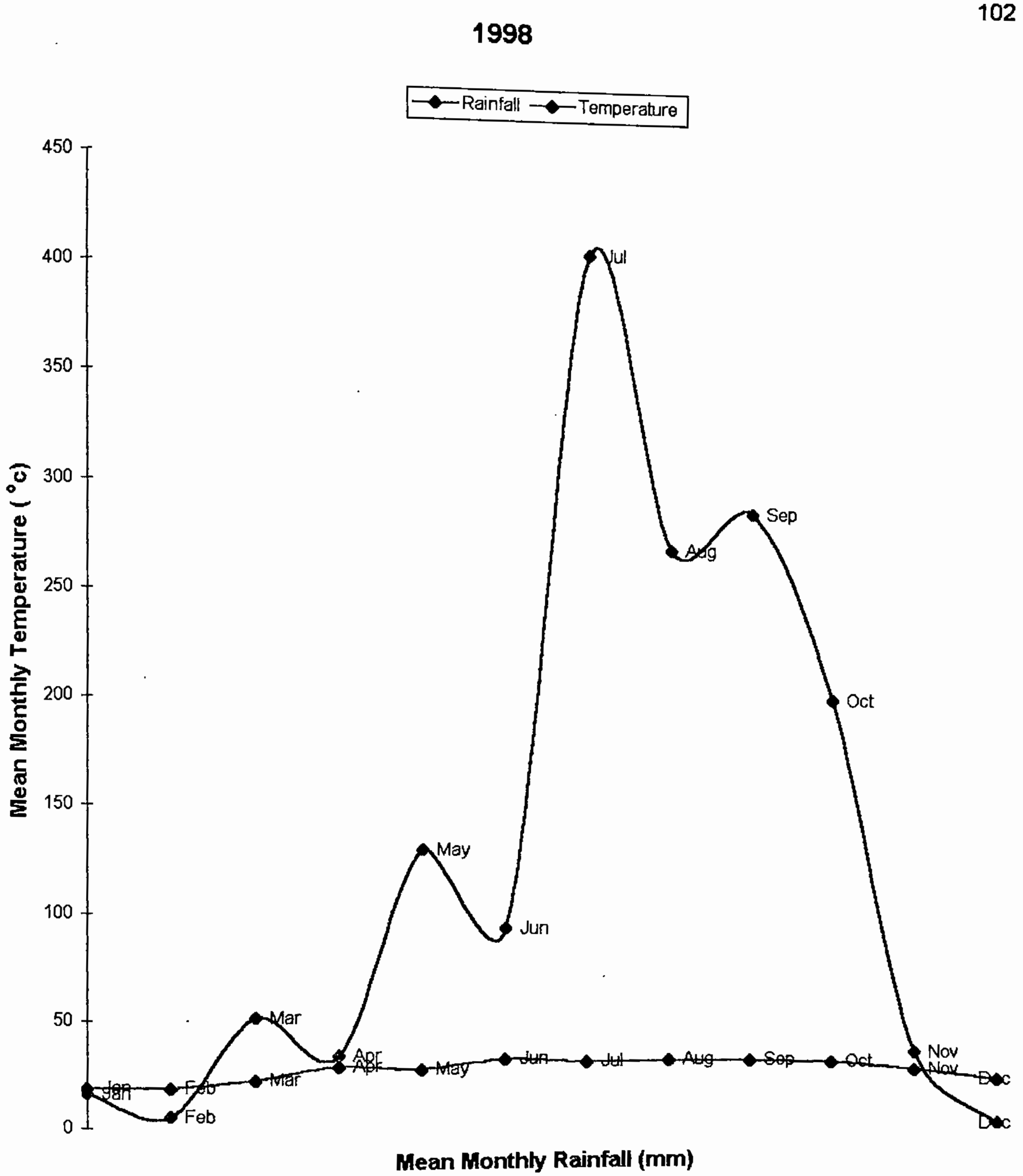


Fig.18 Hytergraph for Rajshahi

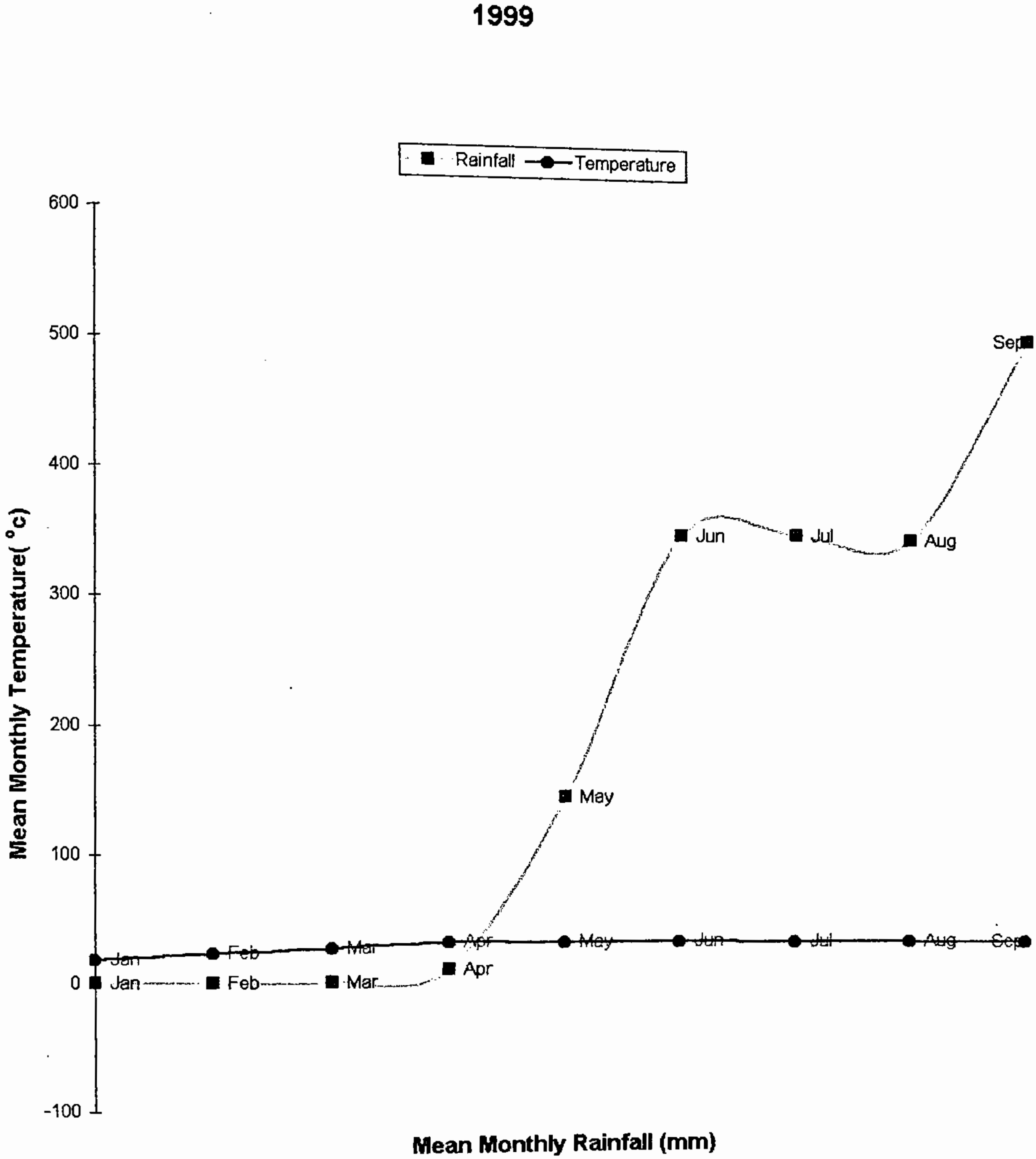


Fig.19 Hythergraph for Rajshahi

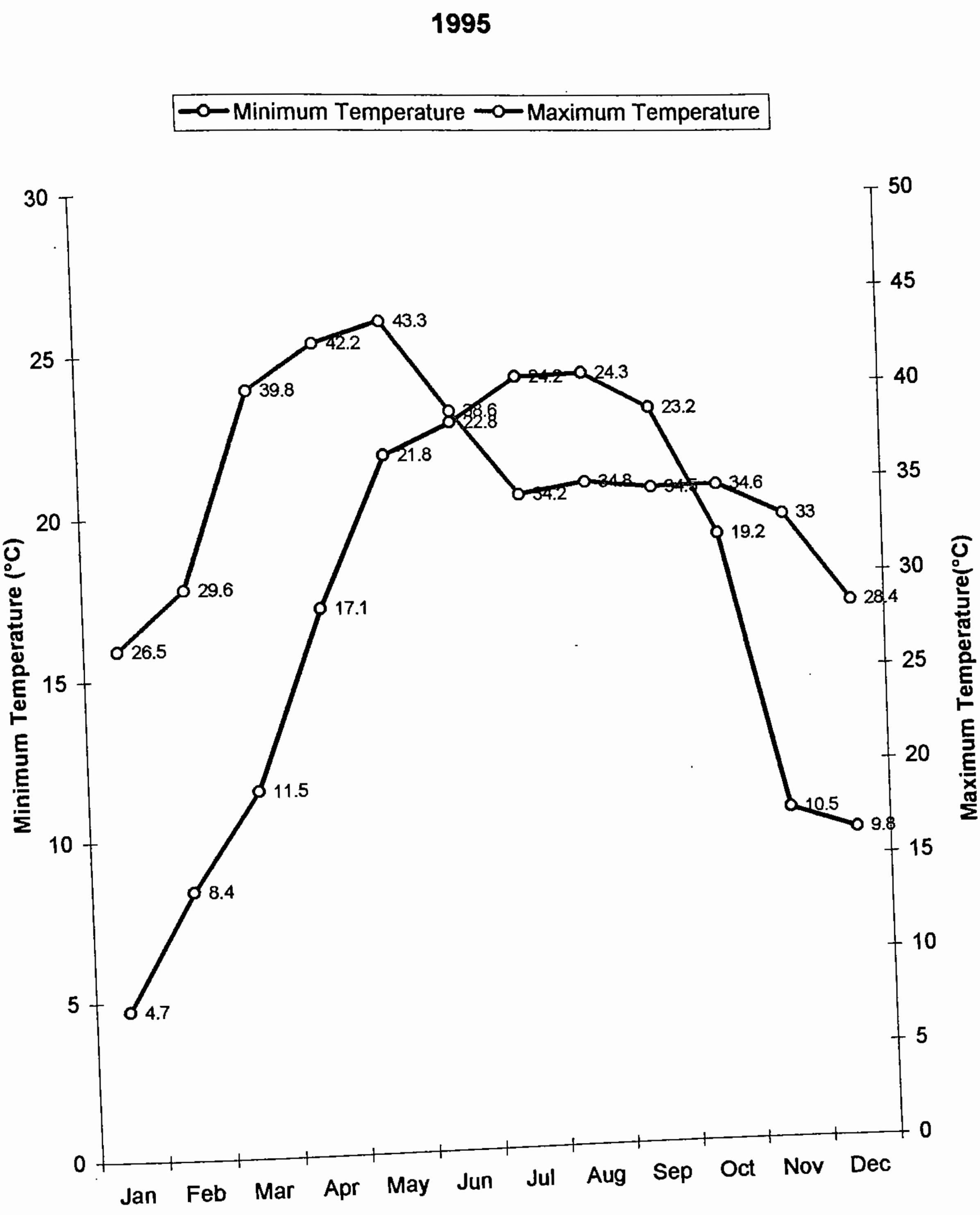
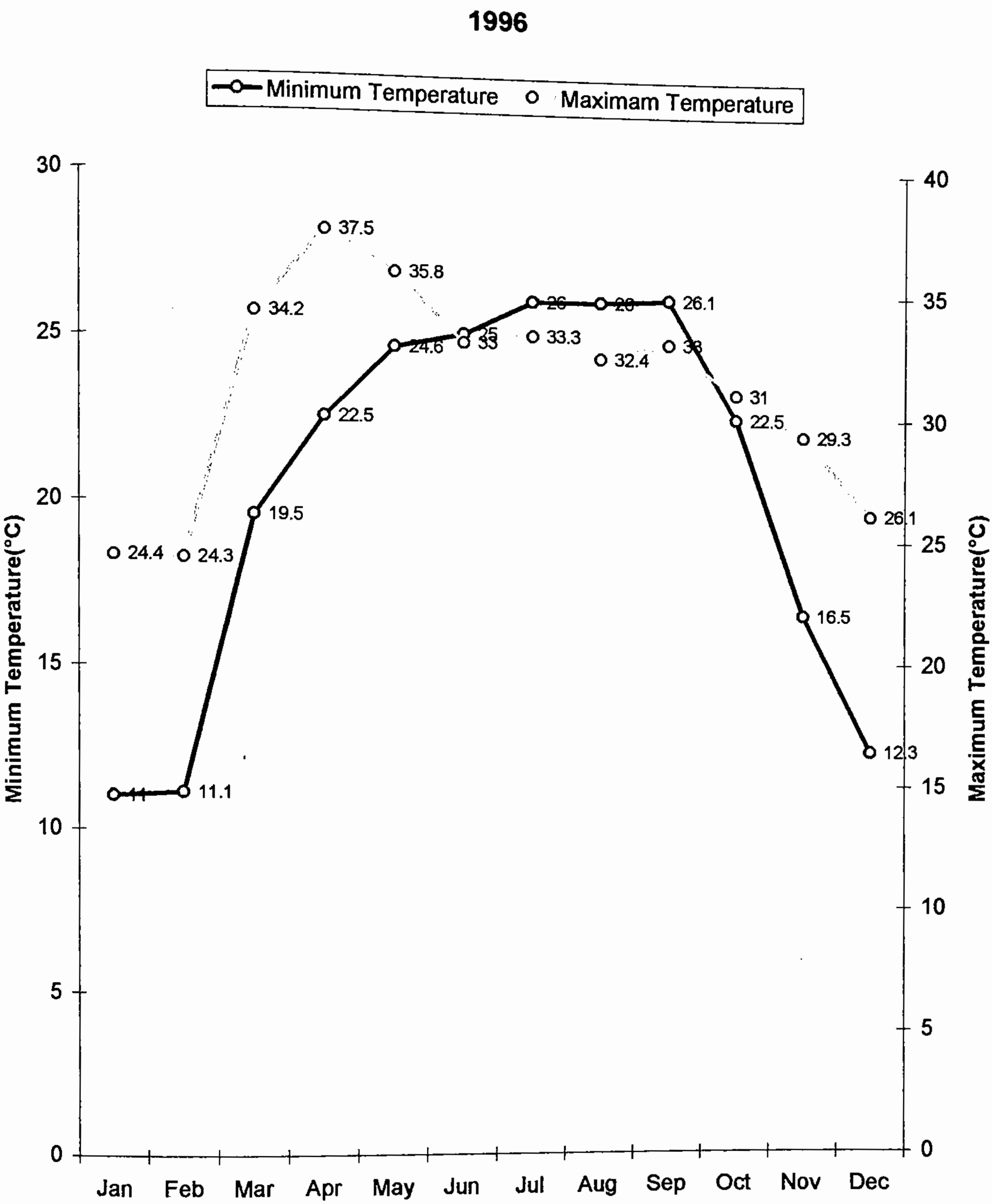


Fig.20 Graphical representation of Maximum and Minimum Temperature



Graphical representation of Maximum and Minimum Temperature

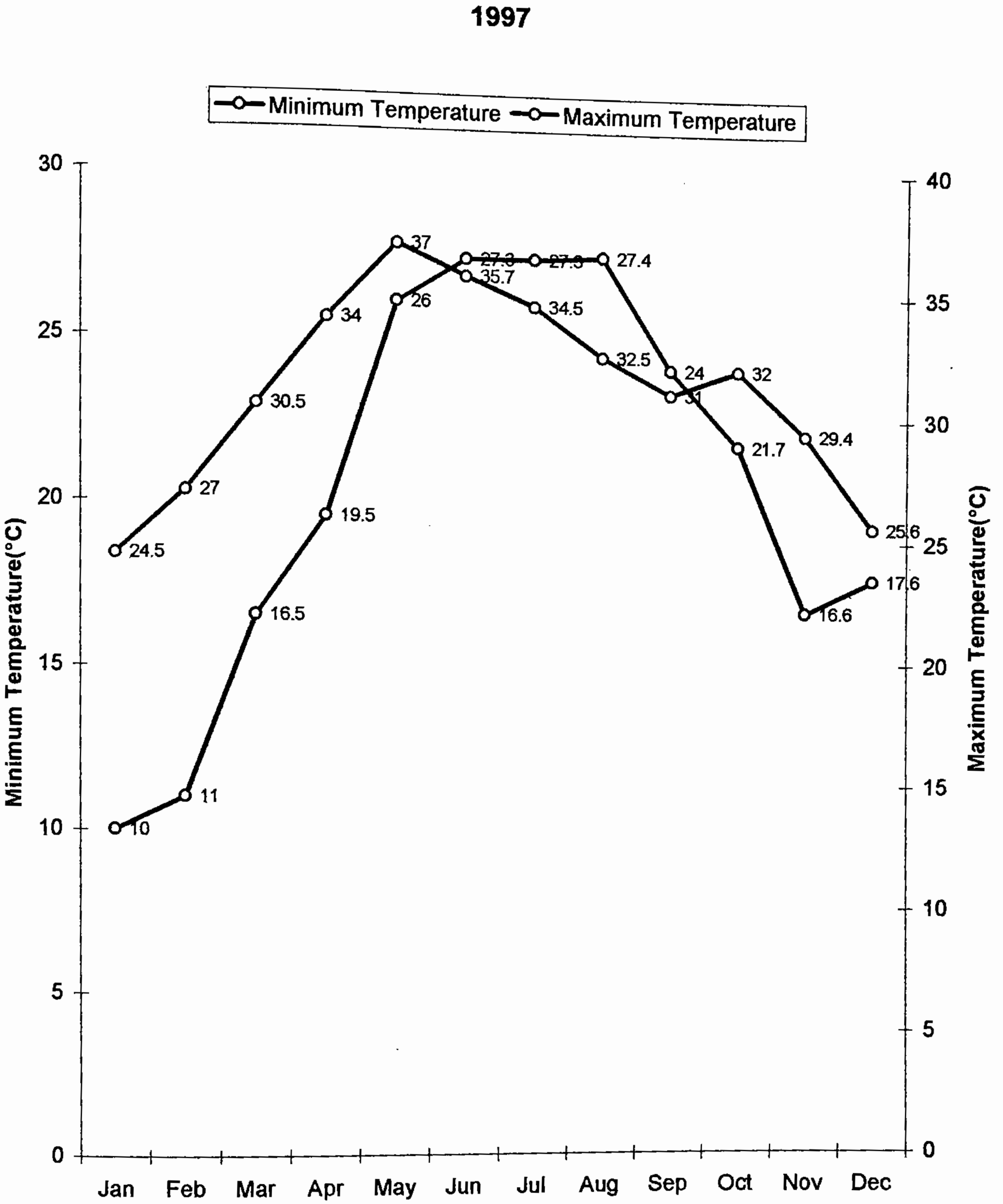


Fig.22 Graphical representation of Maximum and Minimum Temperature

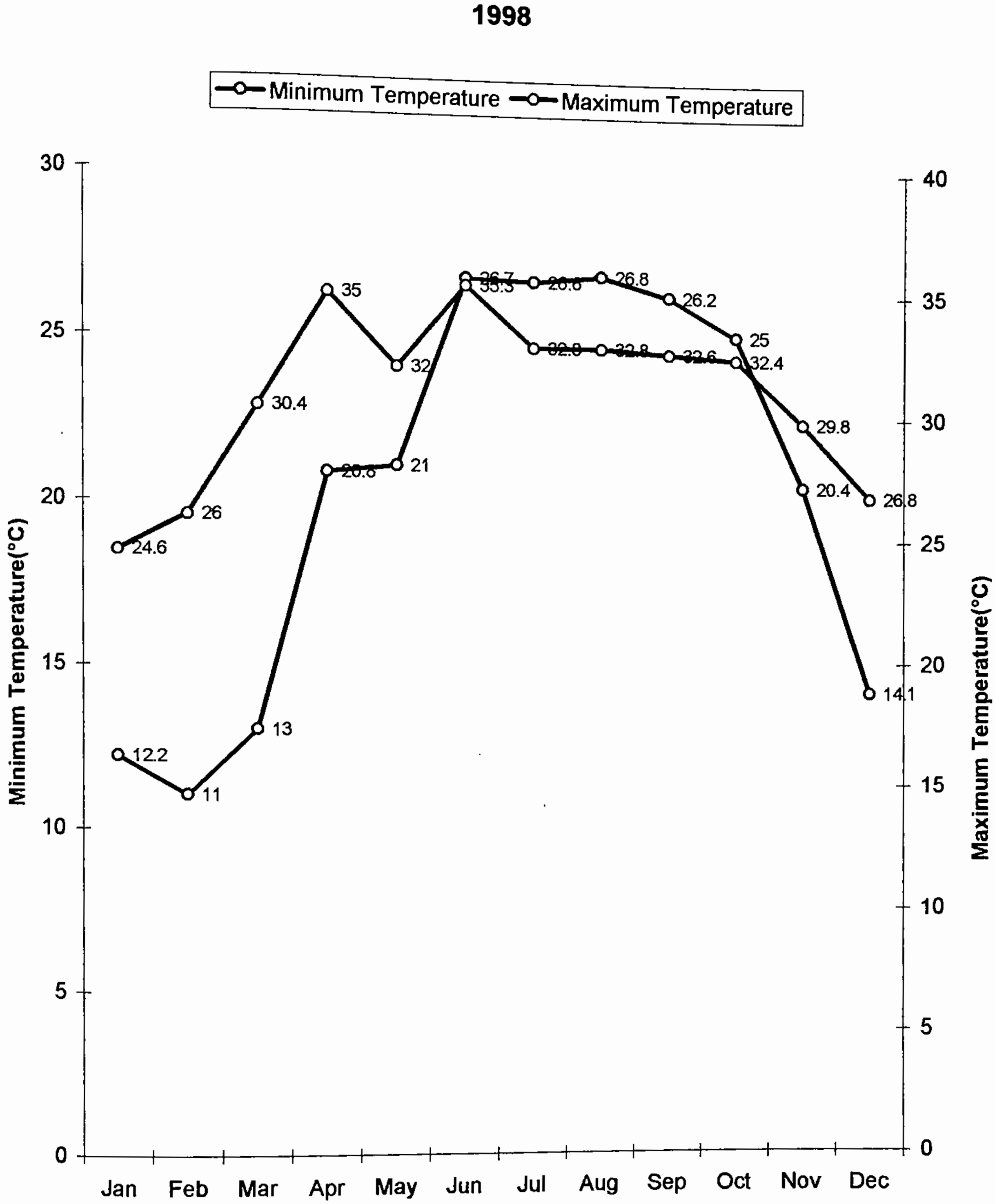


Fig.23 Graphical representation of Maximum and Minimum Temperature

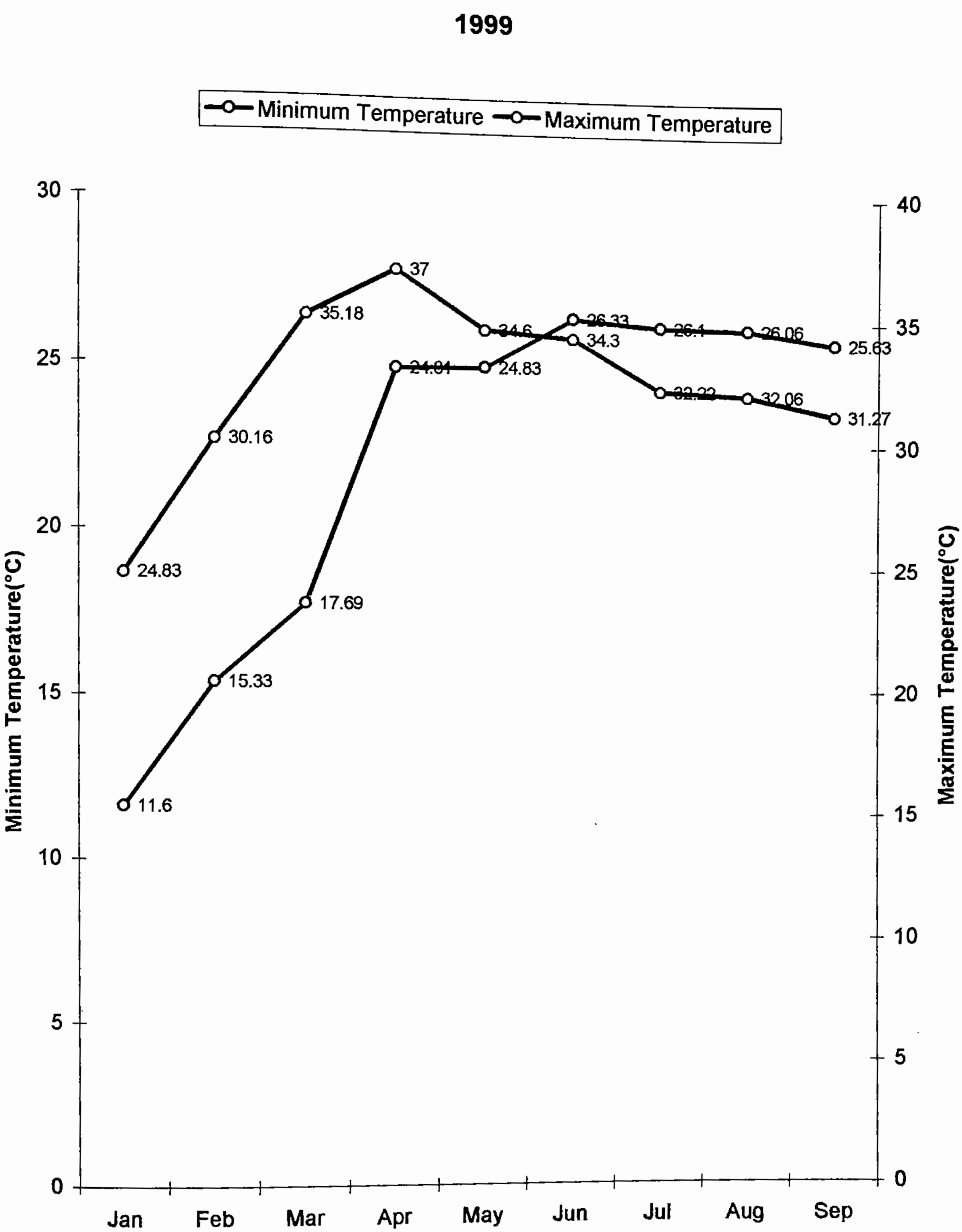


Fig.24 Graphical representation of Maximum and Minimum Temperature

1995

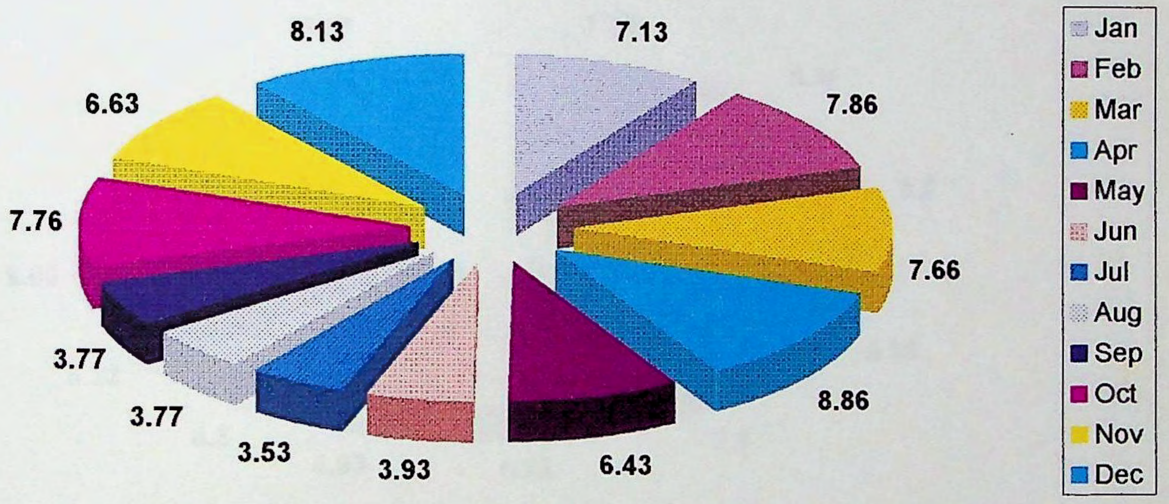


Fig.25 Graphical representation of Bright Sunshine Hour

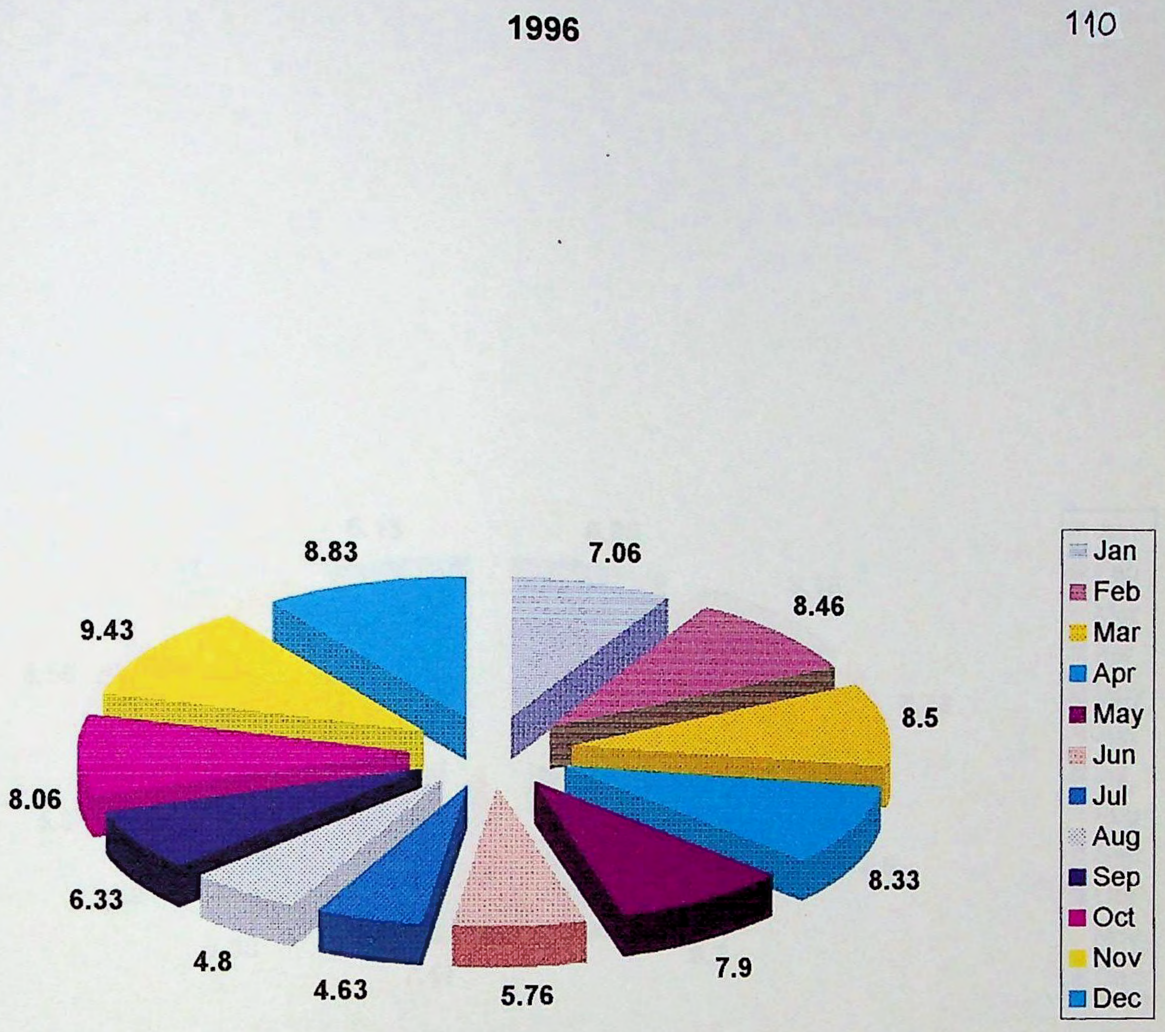


Fig.26 Graphical representation of Bright Sunshine Hour

1997

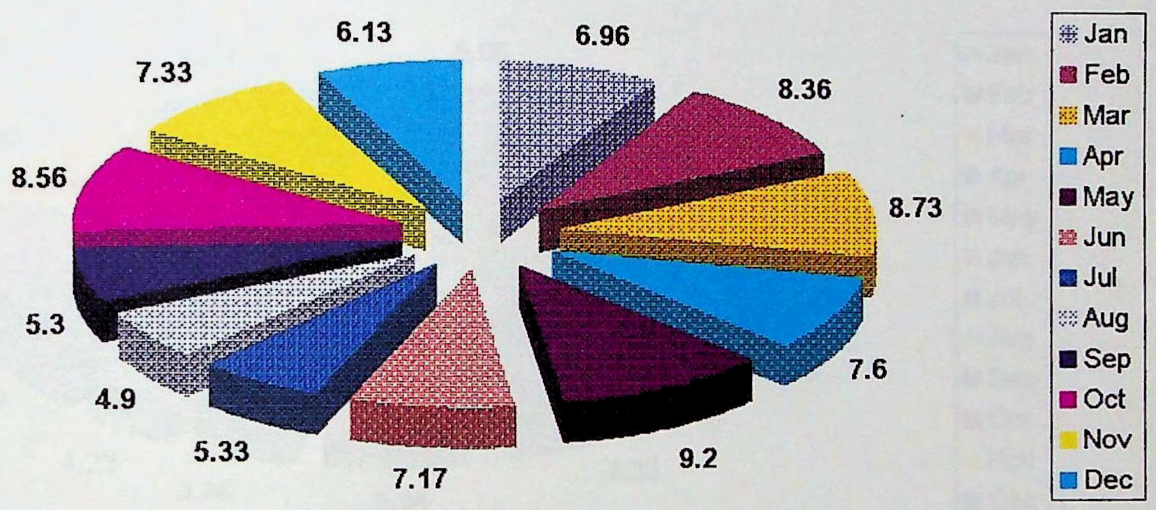


Fig.27 Graphical representation of Bright Sunshine Hour

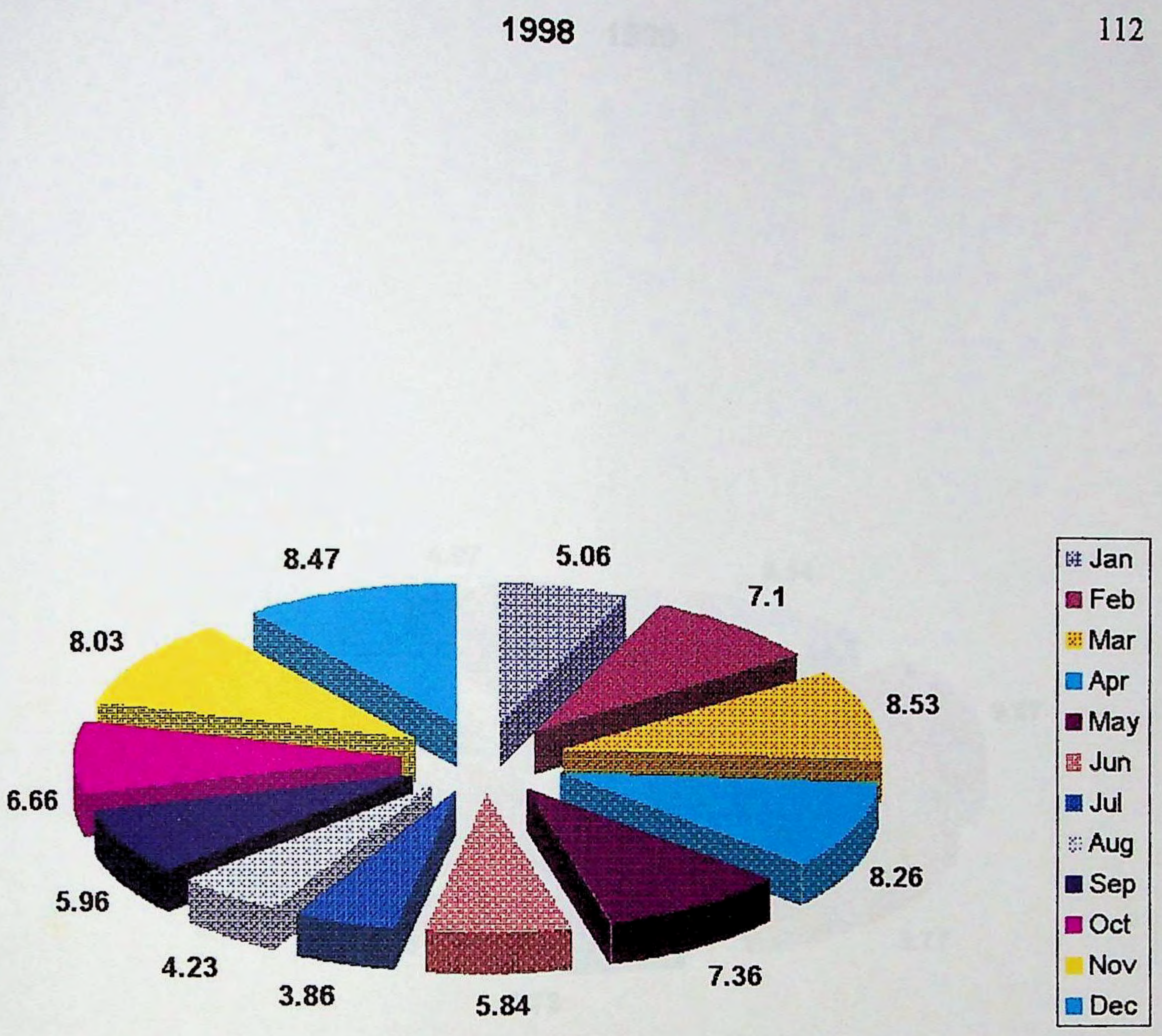


Fig.28 Graphical representation of Bright Sunshine Hour

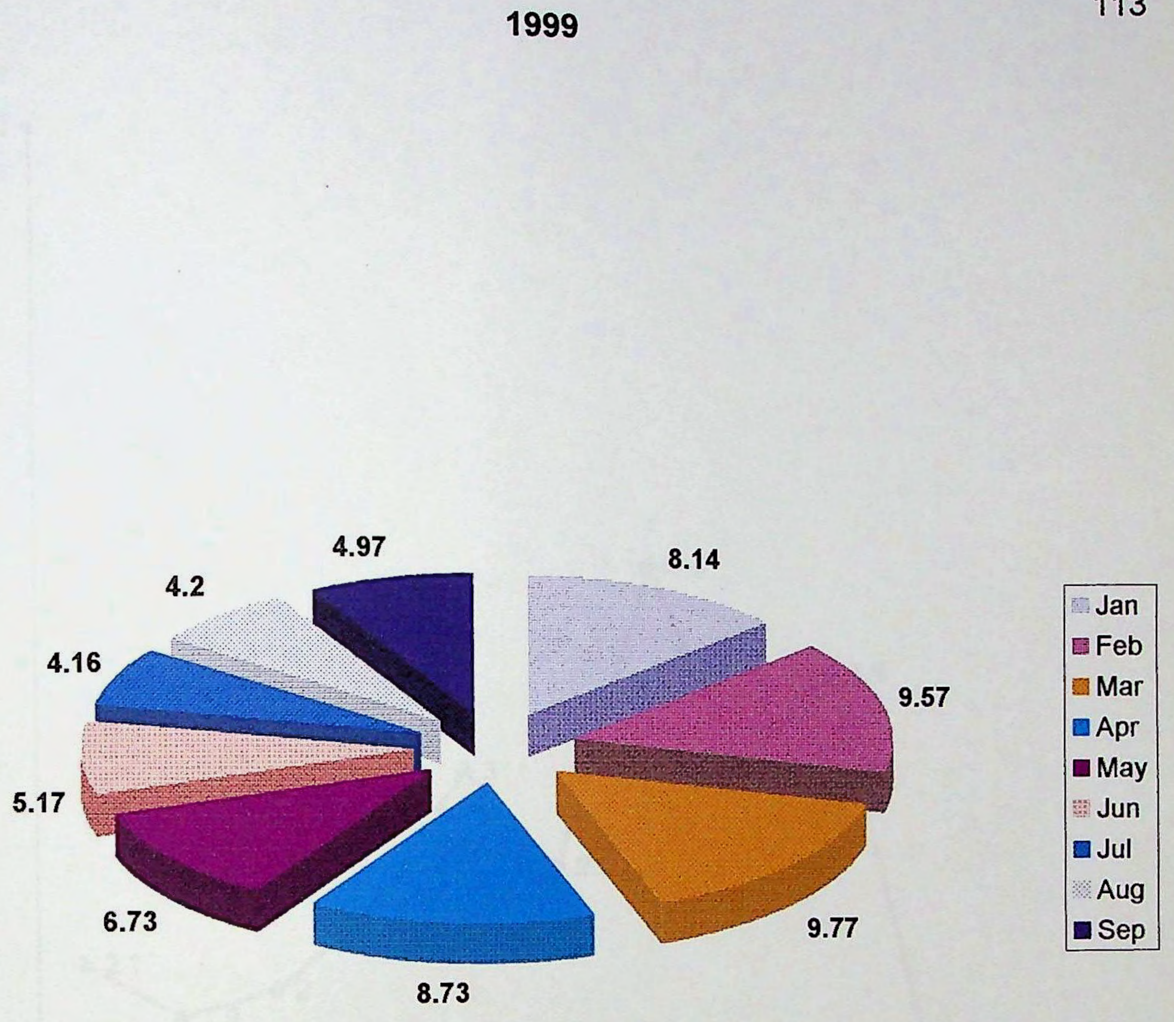


Fig.29 Graphical representation of Bright Sunshine Hour

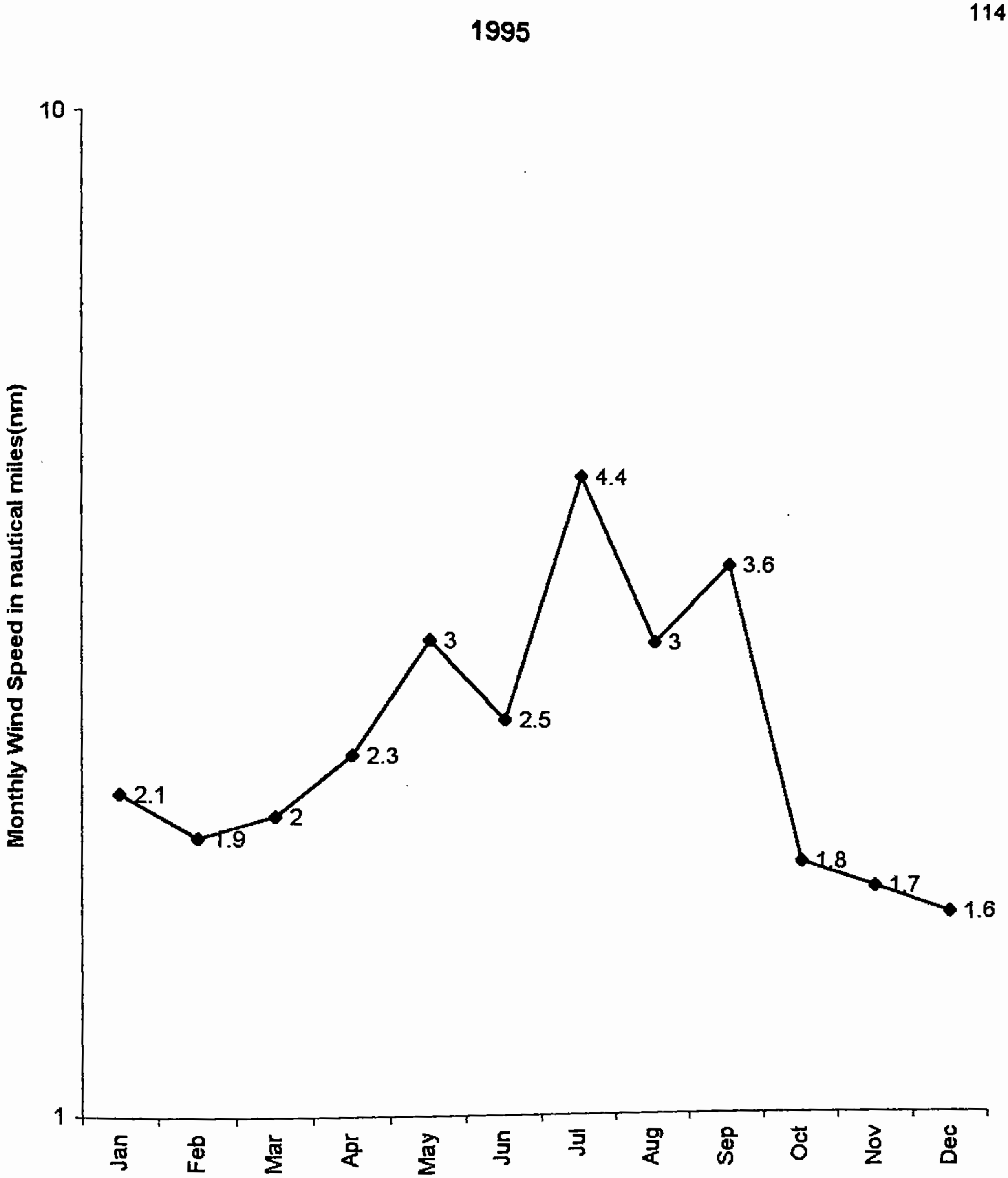


Fig.30 Graphical representation of Wind Speed

1996

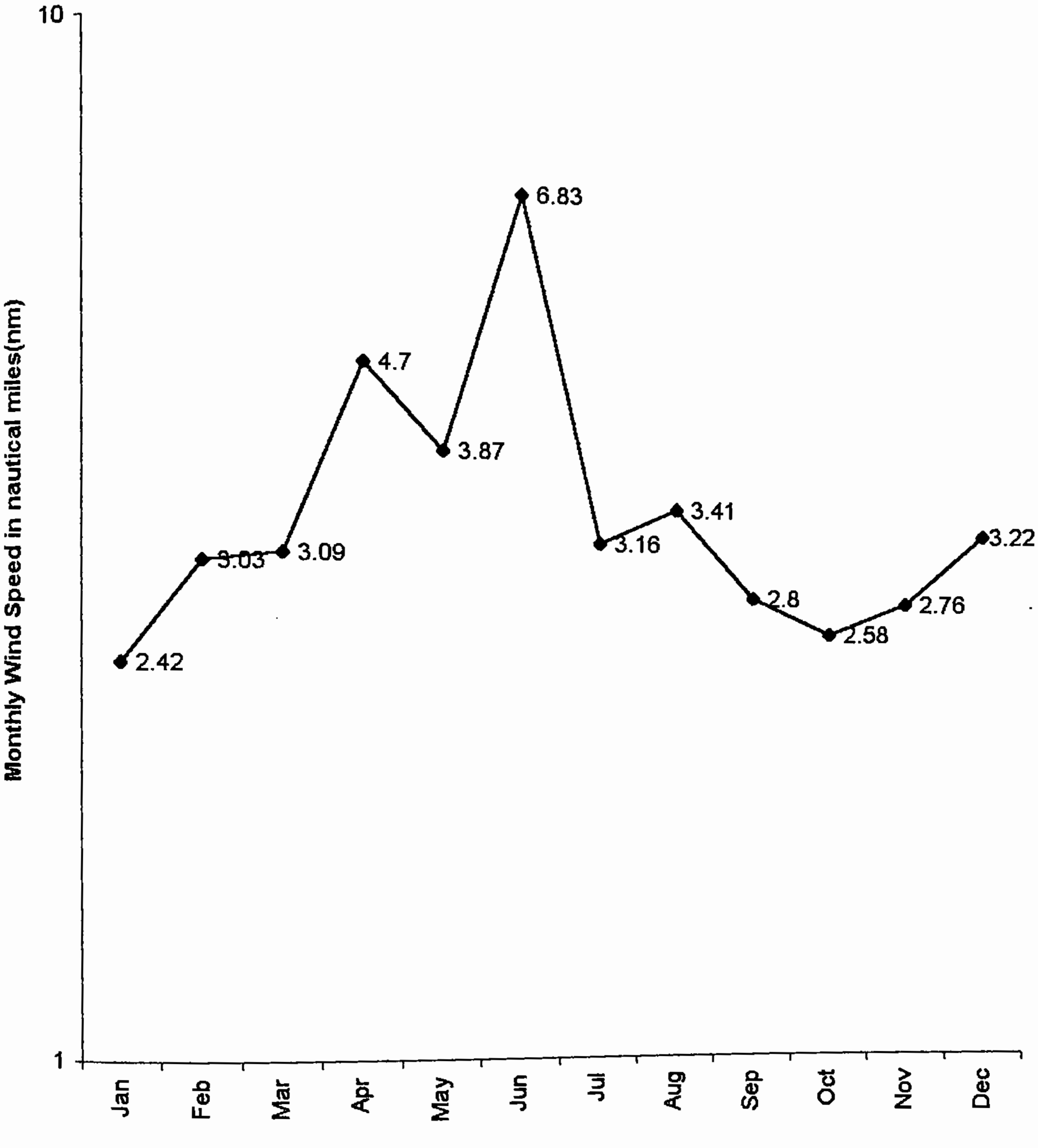


Fig.31 Graphical representation of Wind Speed

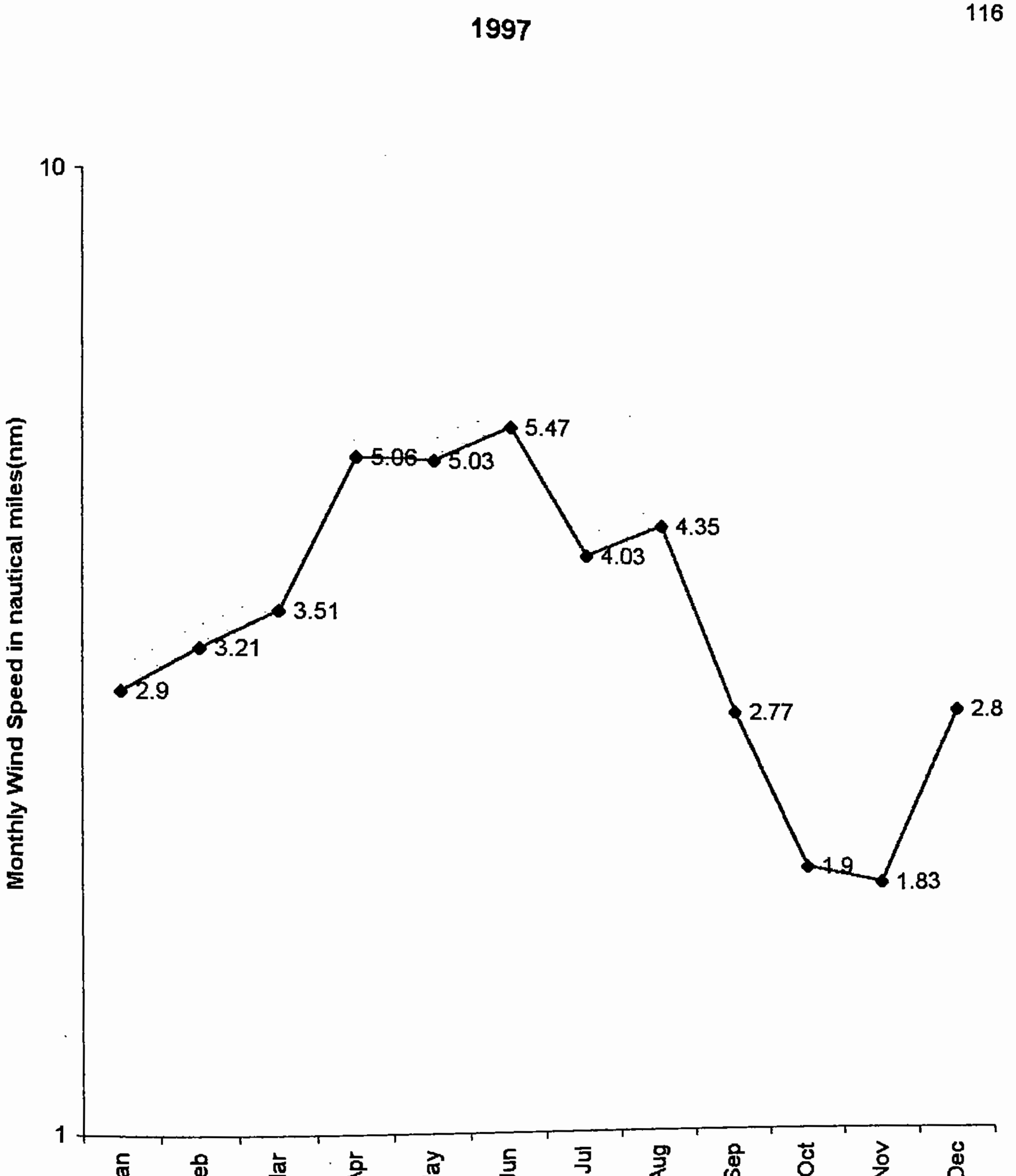


Fig.32 Graphical representation of Wind Speed

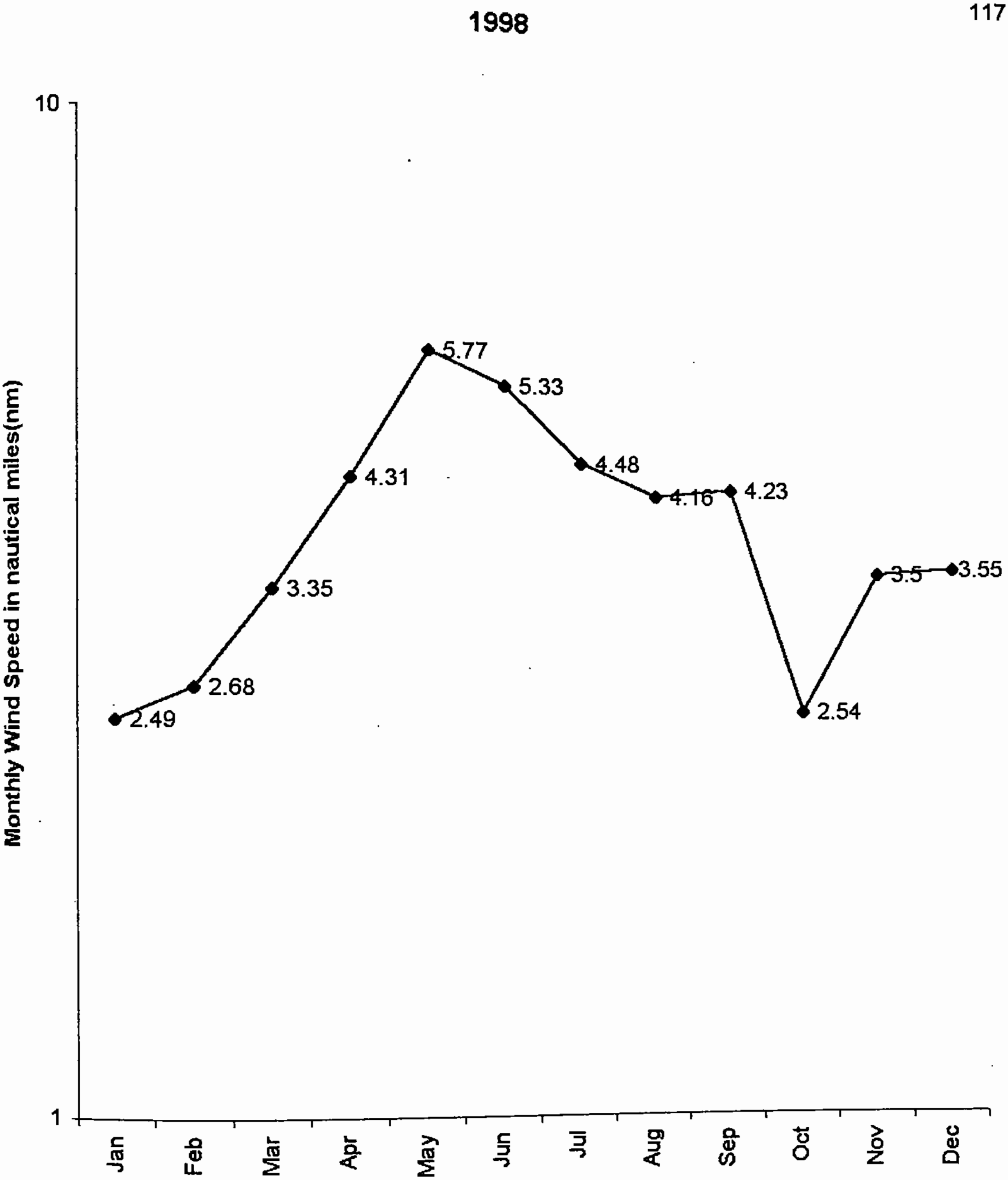


Fig.33 Graphical representation of Wind Speed

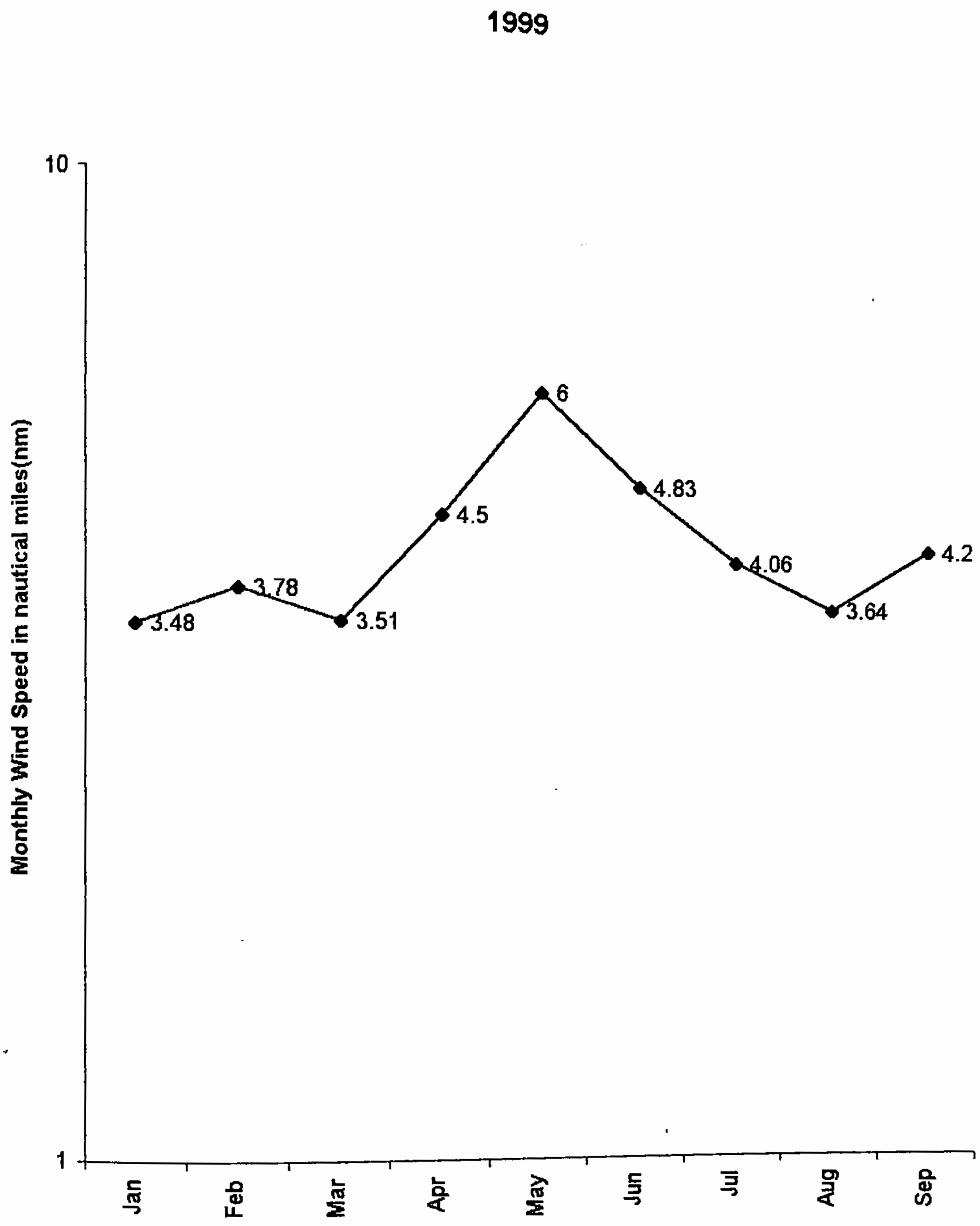


Fig.34 Graphical representation of Wind Speed

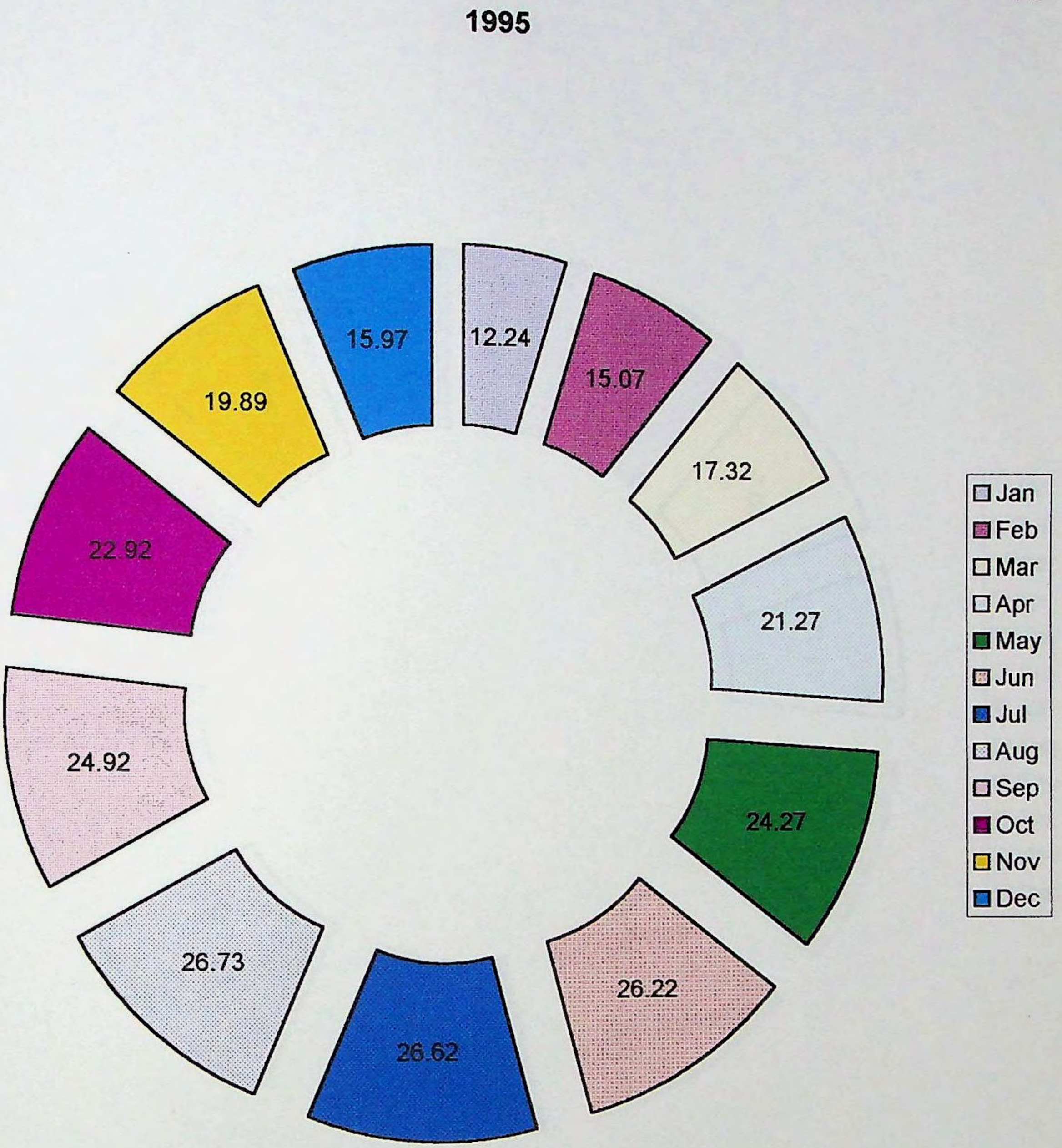


Fig.35 Graphical representation of Dew Temperature (°C)

1996

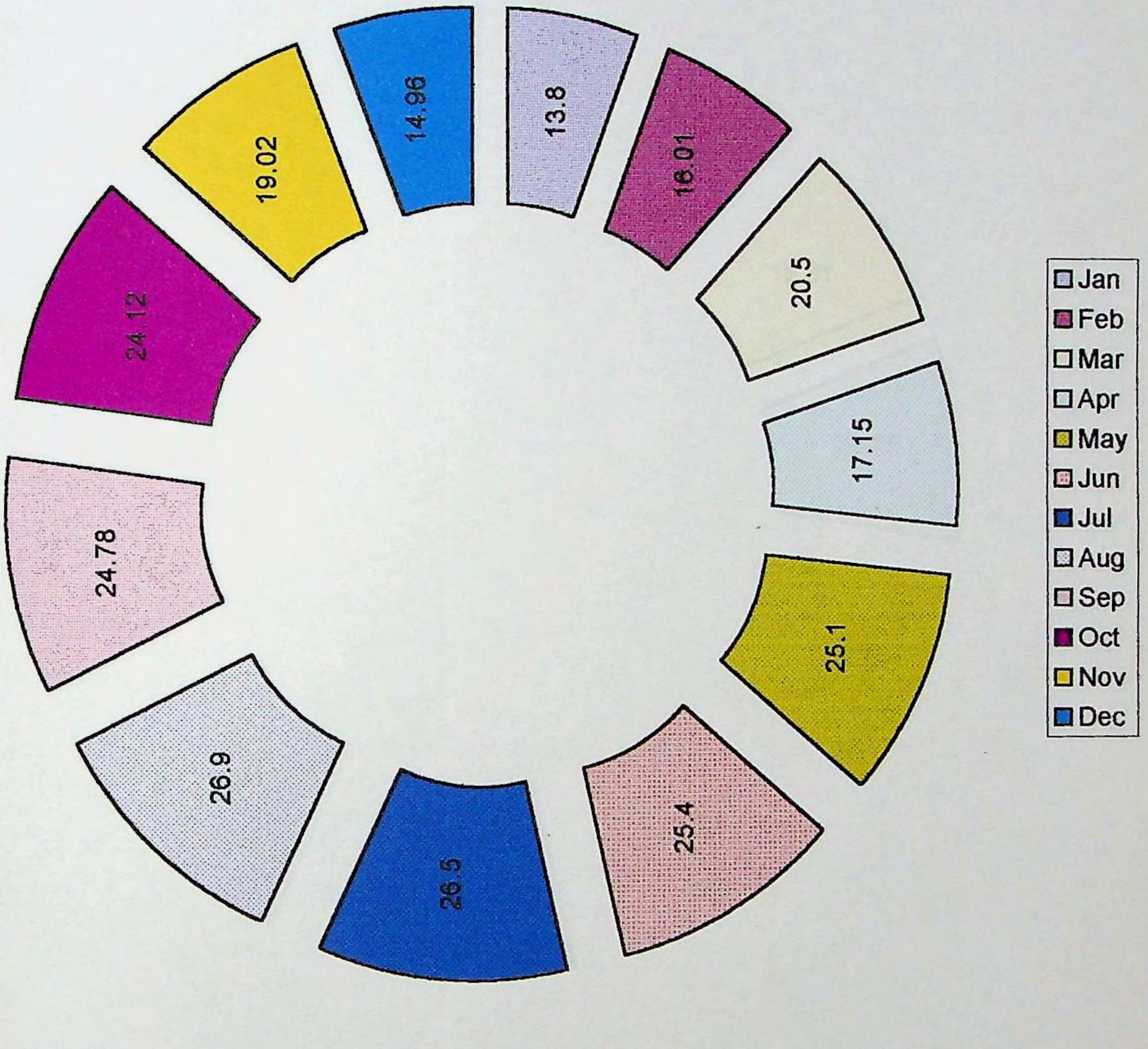


Fig. 36 Graphical representation of Dew Temperature (°C)

1997

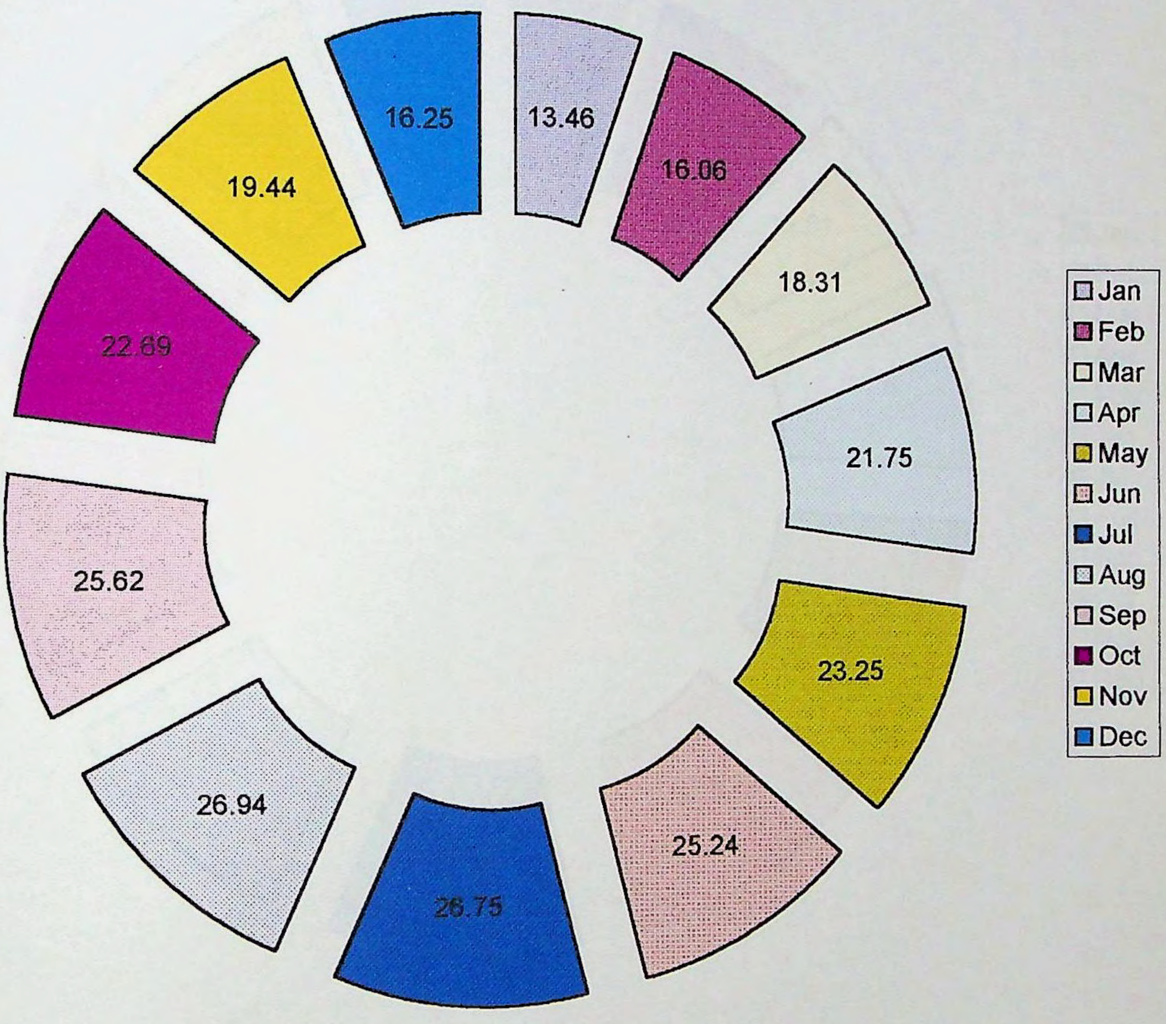


Fig.37 Graphical representation of Dew Temperature (°C)

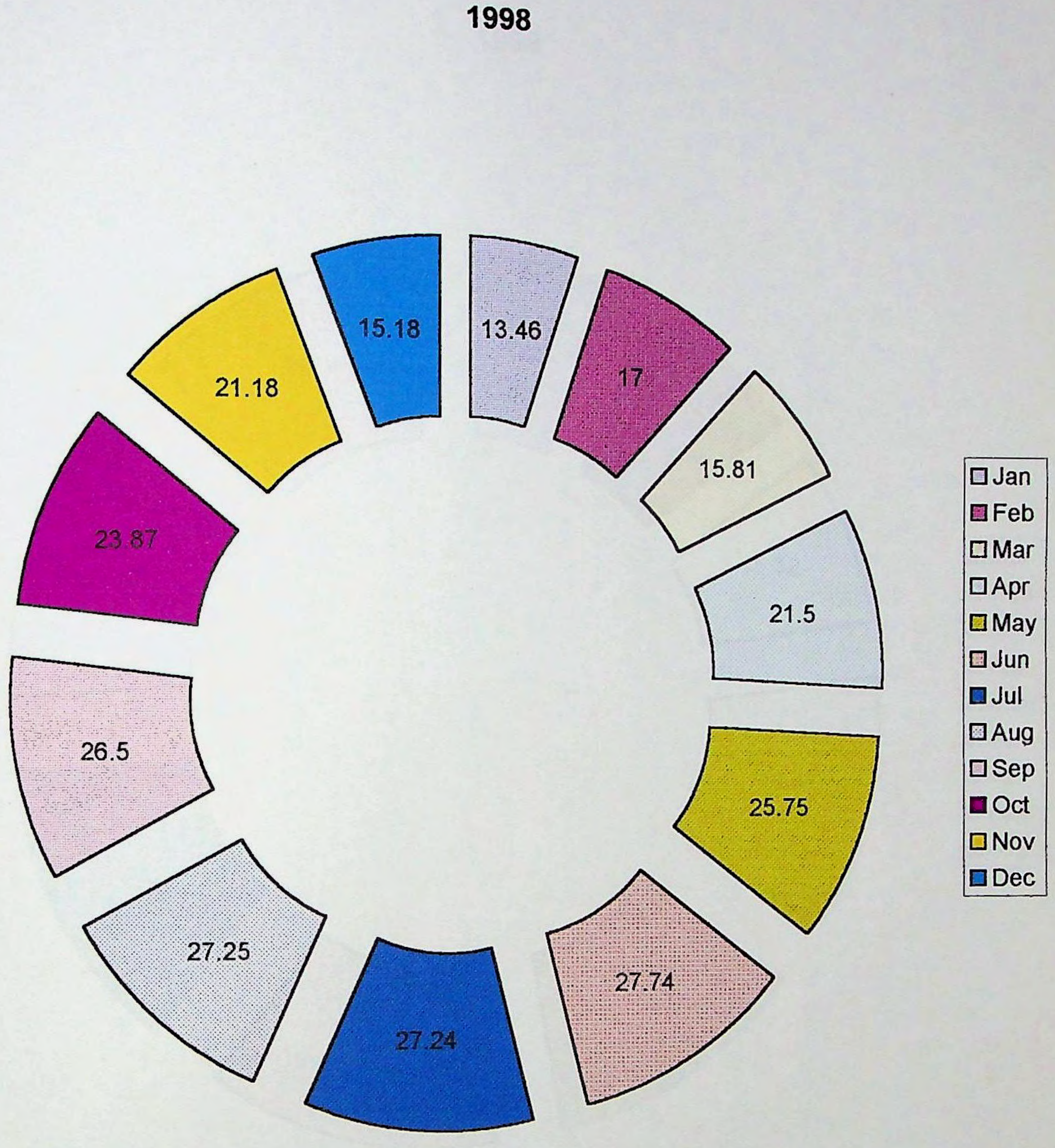


Fig.38 Graphical representation of Dew Temperature (°C)

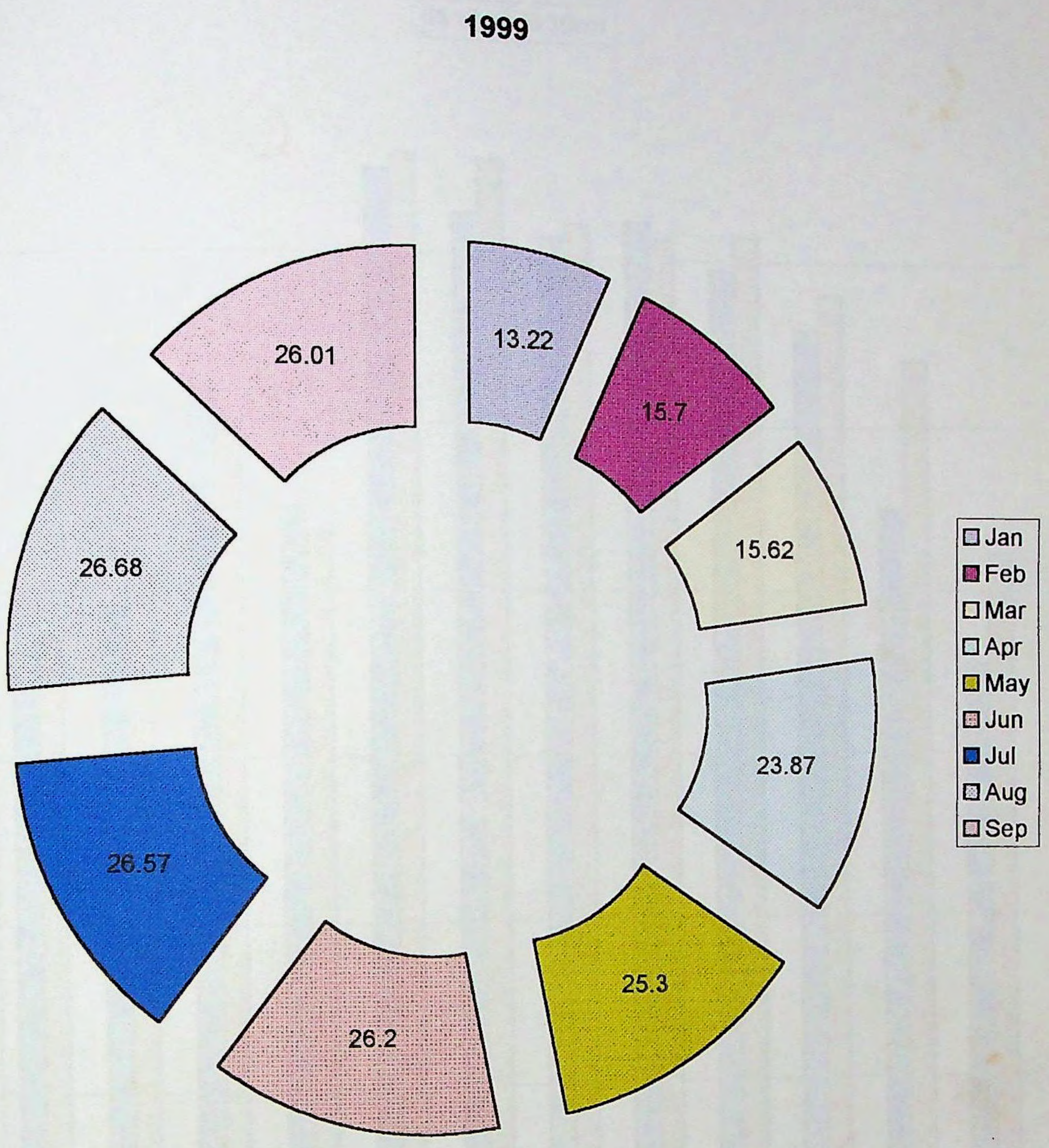


Fig.39 Graphical representation of Dew Temperature (°C)

Fig. 40 Graphical representation of Soil Temperature (°C)

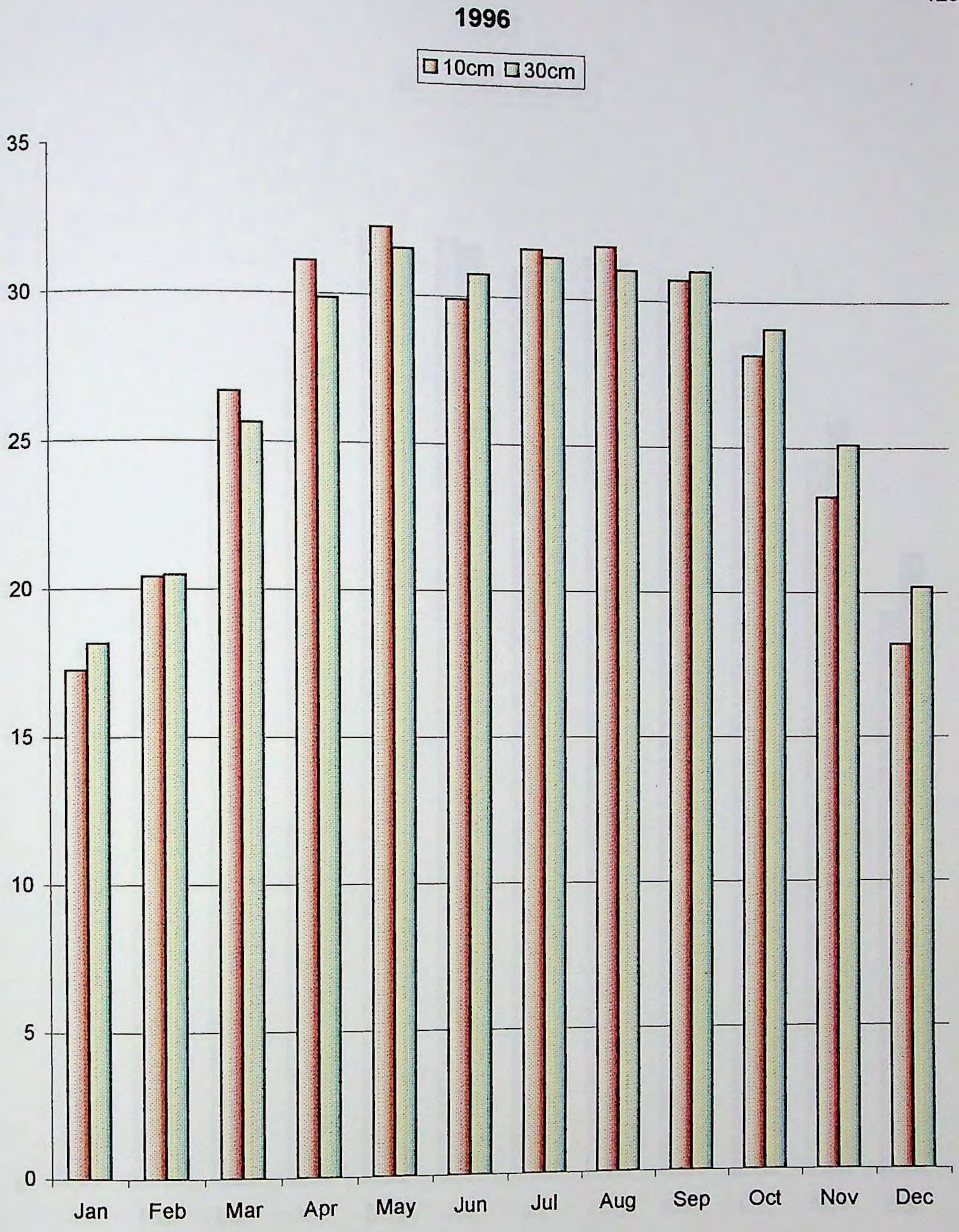


Fig. 41 Graphical representation of Soil Temperature(°C)

Fig. 42 Graphical representation of Soil Temperature (°C)

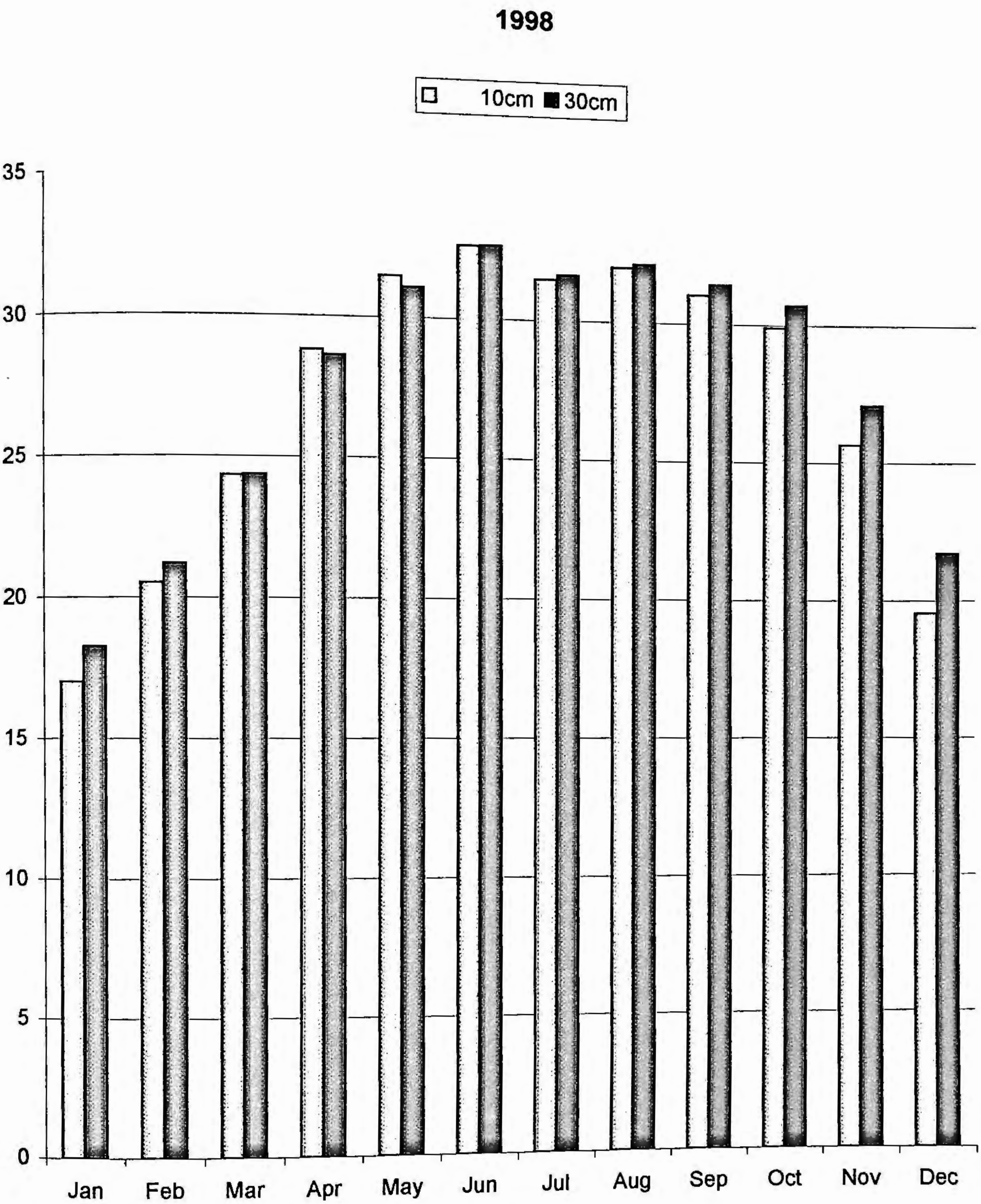


Fig. 43 Graphical representation of Soil Temperature (°C)

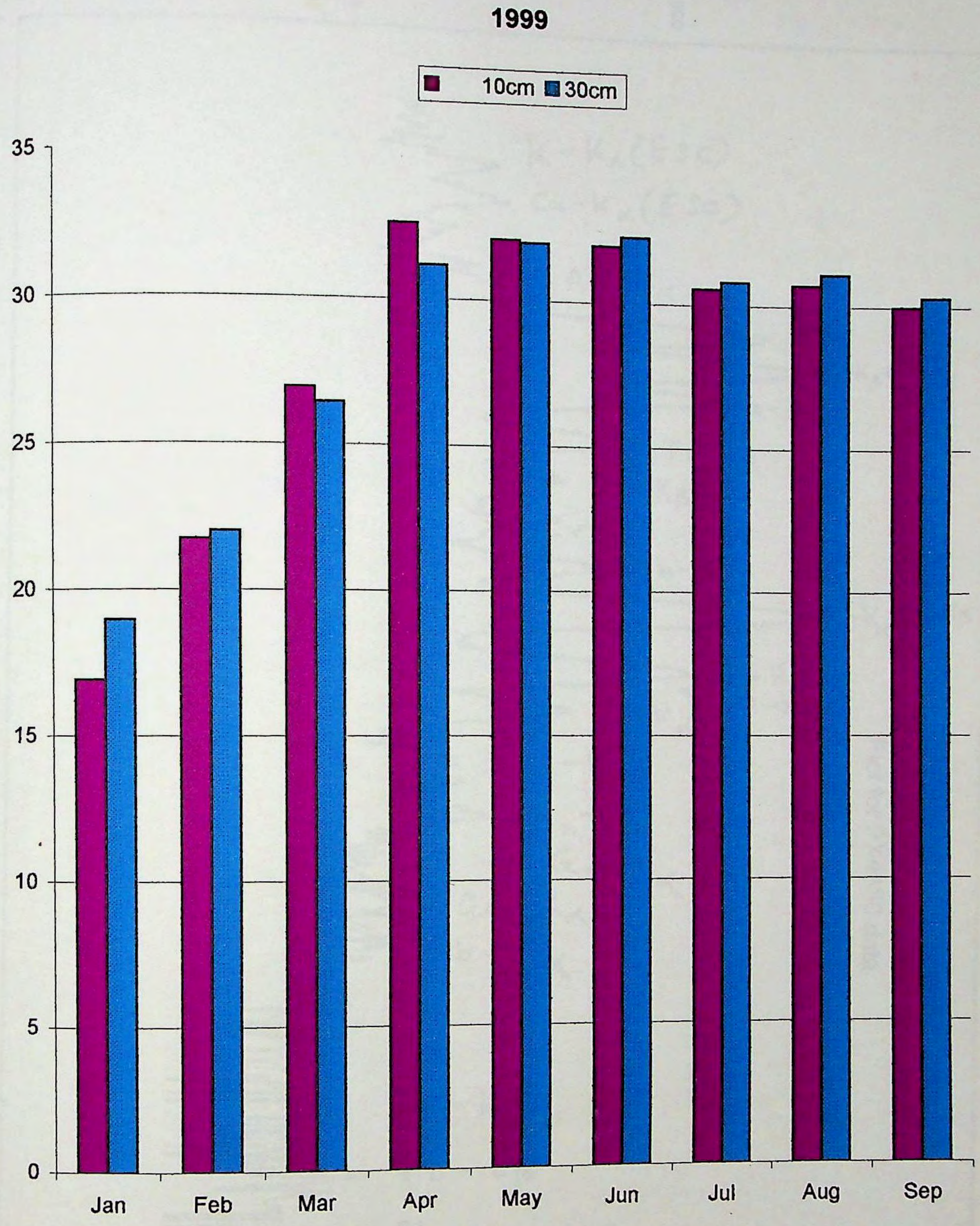
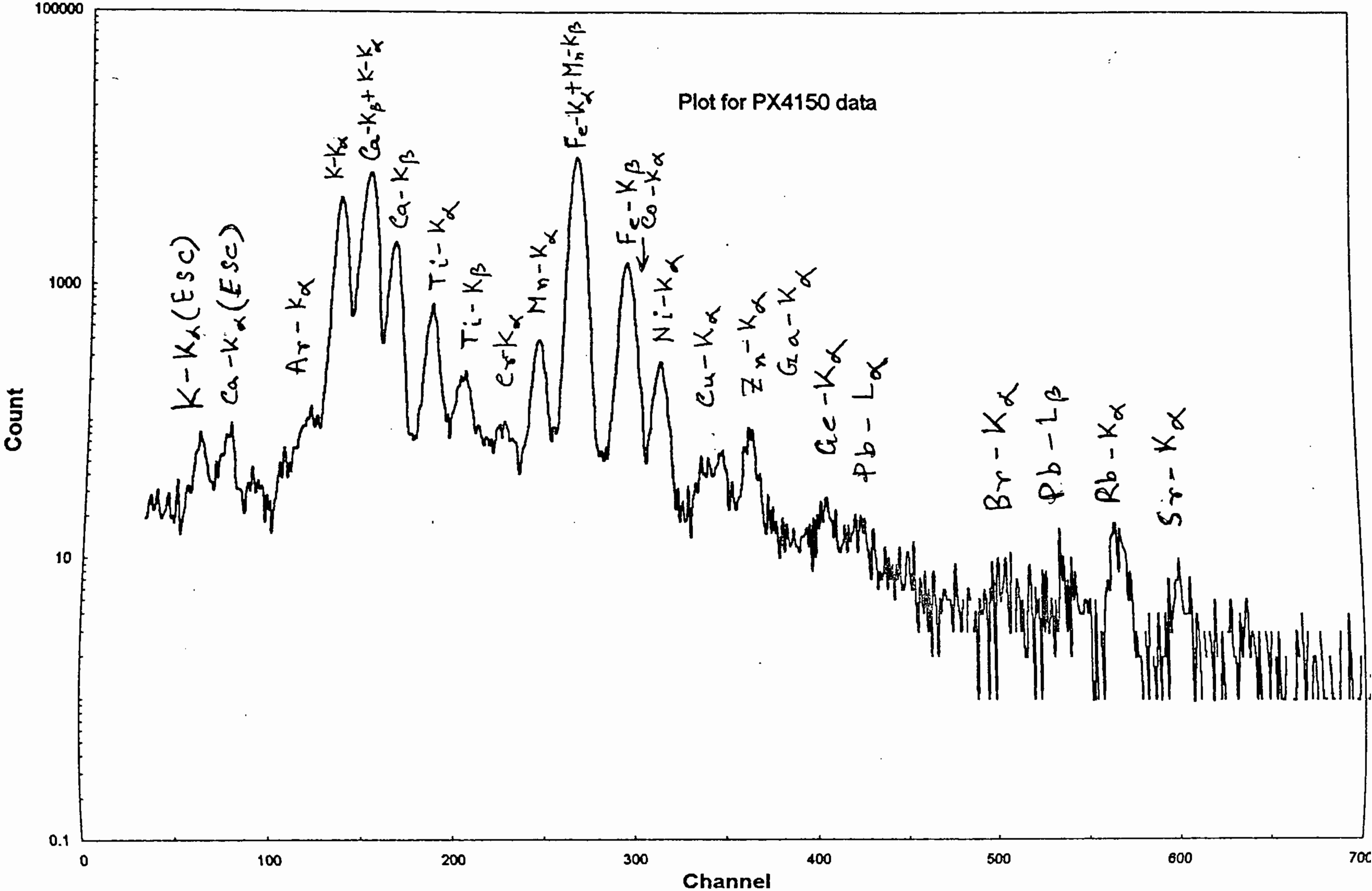


Fig. 44 Graphical representation of Soil Temperature (°C)

Fig-9 : Characteristic X-ray spectrum of vegetable



Chapter - 5

Conclusion

In this present work, we see that the humidity of Rajshahi is high throughout the year. Only on certain days when the hot paschi (a hot dry western wind) blows strongly, the humidity does drop quite low. March and April are the least humid months in Rajshahi. Humidity is found to be above 80% during June, July, August and September. The above findings are also in good agreement with those of others [R-45].

In the monsoon season the rainfall occurred in higher scale whereas that occurred in lower scale during winter season.

The highest temperatures are recorded in the months of March, April and May. There is a period of equable temperatures from July to September, June being a transitional period. There is a steady fall in maximum and minimum temperatures from October to the end of December. The coolest period is from the last week of December to the last week of January; February is a transitional month, leading to the next three hot and dry months.

Among all the seasons the summer and the post monsoon seasons bear the highest bright sunshine hour. On the other hand the lowest sunshine hour occurred during the monsoon season as expected.

In December, we observed wind to flow at a minimum speed whereas wind flows at a maximum speed in June.

Dew temperature was found to have the highest value during the summer season and that found lowest during the winter season.

The temperature of soil was observed to increase gradually from January to June and then found to fall from July to December.

According to Koppen classification of climatic zone, Rajshahi City comes under the perview of Am zone. Am implies that the Tropical monsoon: Hot, seasonally excessive rainfall.

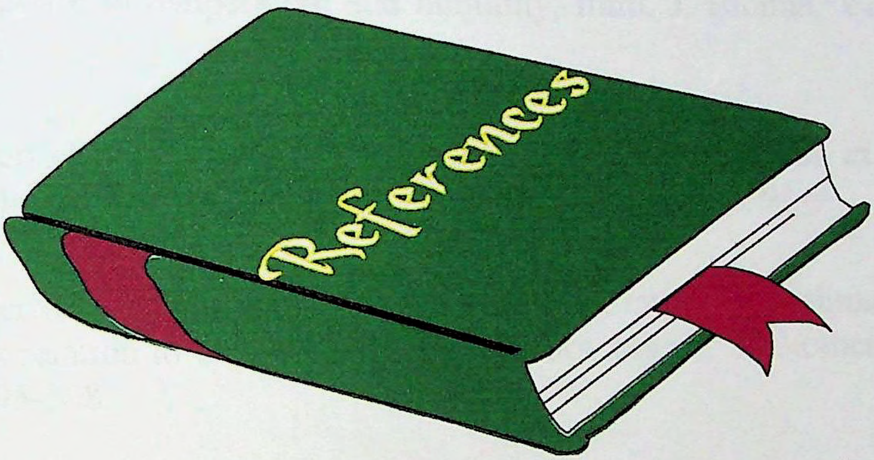
According to De Martonae classification, Rajshahi is the Less vegetation area.

The climate of Rajshahi is characterised by high temperatures, with rainfall generally below 150mm and summer humidity less then 70%. In summer, Rajshahi is the hottest and driest district in Bangladesh. Our observations are also in good agreement with those of others [R-47]. Usually extreme temperatures are observed in Rajshahi during winter and summer seasons. This may be due to growth of huge sandslits and drastic fall of water level in the river Padma. This effect may possibly be restricted through proper river dredging and even by constructing a barrage over the river for restoring water level upto a certain height during rainy seasons,As these will involve huge budget, more data and serious analysis will be needed to draw concrete conclusion. As such regular monitoring of temperature and other related environmental parameters of this city is needed.

Trace elements including heavy metals in different winter vegetables were determined using PIXE technique. In total 19 elements (K, Ca, Ti, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Br, Rb, Sr, Zr, Mo, Pb) were found in vegetable samples in different concentrations. In the samples, K, Ca, and Fe are present at higher concentrations. But K has the highest concentration level among all other trace elements. The rest of the elements occurred in the samples at relatively lower concentrations.

The concentrations of As, Cu, and Zn are well below the maximum permissible concentration (MPC) value where the MPC value of As is 1μg/gm, Cu is 50 μg/gm and Zn is 40-50 μg/gm [R-48]. But in case of Pb, our concentrations are greater than the MPC value, which is 2-2.5 μg/gm [R-48]. Due to non availability of the MPC value for the rest of the elements, it is not possible to draw a conclusion regarding this. Our findings are in agreement with those of others excluding K and Fe (Table-25). Therefore, much more works required to be done in future in this field.

However we are quoting the MPC value of some other trace elements in water (see Appendix 1 & 2).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