In the Name of God

Pollution Effects of the Persian Gulf War on the Southern Regions of Iran

Soudabeh Ali Ahmad Korori

Anoushirvan Shirvany

Mostafa Khoshnevis

Mohammad Matinizadeh

Research Group of Sustainable Natural Ecosystems of Iran

عنوان و نام پدیدآور : Pollution effects of Persian Gulf waron the southern regions of Iran
Soudabeh Ali Ahmad Korori ... [et al.];] for] Research Group of
Sustainable Natural Ecosystems of Iran.
مشخصات نشر : تهران: جهاد دانشگاهی، واحد تربیت معلم، ۲۰۱۱م.= ۱۳۸۹.
مشخصات ظاهری : ۳۸۰ ص.: مصور (رنگی)، جدول، نمودار (بخشی رنگی).
شابک : ۱۸۵۰۰۰ ریال: 978-964-6653-81-8
وضعیت فهرست نویسی : فیپا
یادداشت : انگلیسی
یادداشت : Soudabeh Ali Ahmad Korori, Anoushirvan Shirvany, Mostafa Khoshnevis.
یادداشت : کتابنامه
یادداشت : نمایه
موضوع : جنگ خلیج‌فارس، ۱۹۹۱م. -- ایران -- خسارات و خرابی‌ها
موضوع : محیط زیست -- خلیج فارس، منطقه
موضوع : آلودگی نفتی دریاها -- خلیج فارس -- تاثیر بر محیط زیست
شناسه افزوده : علی احمد کروری، سودابه، ۱۳۲۵ -
شناسه افزوده : جهاد دانشگاهی. واحد تربیت معلم
رده بندی کنگره : DSR۲۱۳۴/پ۹ ۱۳۸۹
رده بندی دیویی : ۹۵۵/۷۲۵
شماره کتابشناسی ملی : ۲۰۱۳۲۲
تاریخ درخواست : ۱۳۸۹/۱۰/۲۸
تاریخ پاسخگویی : ۱۳۸۹/۱۱/۰۲
کد پیگیری : ۲۲۲۹۱۵۵

جهاد دانشگاهی
واحد تربیت معلم

انتشارات جهاد دانشگاهی واحد تربیت معلم

شابک : ۸- ۸۱ - ٦٦٥٣ - ٩٦٤-٩٧٨

ISBN :978- 964 - 6653 - 81 - 8

نام کتاب : Pollution Effects of the Persian Gulf War on the Southern Regions of Iran

تألیف : سودابه علی احمد کروری / انوشیروان شیروانی / مصطفی خوشنویس / محمد متینی زاده

نوبت چاپ اول : بهار ۱۳۹۰

لیتوگرافی : پویش

چاپ : دانشگاه تربیت معلم

شمارگان : ۱۰۰۰

قیمت : ۱۸۵۰۰۰ ریال

آدرس ناشر :
تهران - خیابان انقلاب اسلامی - خیابان شهید مفتح - پلاک ۴۹ - دانشگاه تربیت معلم - جهاد دانشگاهی واحد تربیت معلم
تلفن و دورنگار : ۲۵۲٤ ۸۸۳۰ - ۸۸۳۰۹۲۹۲ مرکز پخش : ۷۷۵۰۳۸۲٤

Soudabeh Ali Ahmad Korori, Specialist in Nature Technology (Ph.D.) and Environmental Technology (Post Doc), Bodenkultur University, Vienna- Austria. Head of the Research Group of Natural Sustainable Ecosystems (Iran).

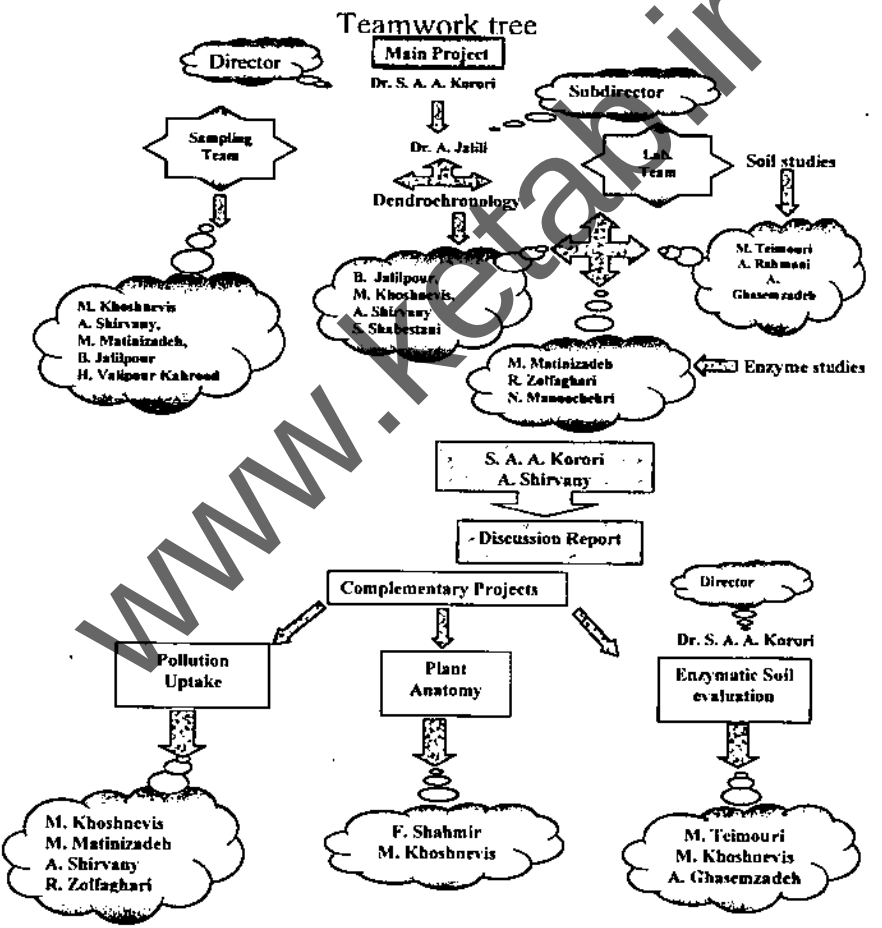
Anoushirvan Shirvany, Ph.D in Forest Genetics, Assistant Professor, Department of Forestry, Faculty of Natural Resources, the University of Tehran.

Mostafa Khoshnevis, MS. in Forestry, Member of Scientific Board, the Research Institute of Forests and Rangelands (RIFR, Iran).

Mohammad Matinizadeh, PhD. in Nature Technology, Member of Scientific Board, the Research Institute of Forests and Rangelands (RIFR, Iran).

Scientific Group:

Head of the group: Dr. S. A. A. Korori graduated from Bodenkultur University, Vienna Austria, and Specialist in Nature Technology (Ph.D.) and Environmental technology (Post Doc).
Cooperators:
1- A. Shirvany, Ph.D in Forestry,
2- M. Khoshnevis, M.Sc in Forestry,
3- A. Jalili, Ph.D. in Ecology,
4- M. Matinizadeh, Ph.D in Nature Technology,
5- M. Teimouri, M.Sc. in Microbiology,
6- F. Shahmir, M.Sc. in Plant Science,
7- A. Rahmani, Ph.D. in Plant Science,
8- H. Valipour Kahrood, M.Sc in Forestry,
9- S. Shabestani, M.Sc in Silvicultur & Forest Ecology, as well as other Master's and Ph.D students as follows:



Certificate

UNITED NATIONS
SECURITY COUNCIL
UNITED NATIONS
COMPENSATION COMMISSION

NATIONS UNIES
CONSEIL DE SÉCURITÉ
COMMISSION D'INDEMNISATION
DES NATIONS UNIES

Facsimile: (41) (22) 907 0069
Telephone: (41) (22) 917 4442

Villa La Pelouse
Palais des Nations
CH-1211 GENÈVE 10

28 October 2004

Dear Sir or Madam,

I am pleased to provide a letter of reference for Dr. Sudabeh Aliahmad Korury whose work I appreciated in connection with the processing of "F4" environmental damage claims filed before the United Nations Compensation Commission.

The Commission was established by the Security Council to process claims and pay compensation for losses resulting from Iraq's unlawful invasion and occupation of Kuwait. The Commission has received approximately 170 "F4" claims filed by a number of Governments, including the Islamic Republic of Iran, the State of Kuwait, and Kingdom of Saudi Arabia, for damage to the environment seeking a total of approximately US$80 billion in compensation. "F4" claims fall into two broad groups. The first group comprises claims for environmental damage and the depletion of natural resources in the Persian Gulf region including those resulting from oil-well fires and the discharge of oil into the sea. The second group consists of claims for costs incurred by Governments outside of the region in providing assistance to countries that were directly affected by the environmental damage. This assistance included the alleviation of the damage caused by the oil-well fires, the prevention and clean up of pollution and the provision of manpower and supplies.

Due to the complexity of the environmental damage claims and the large claimed amounts involved, at times reaching billions of U.S. dollars, it was often necessary for claimant Governments to conduct detailed monitoring and assessment studies, in order to identify the scope of the environmental damage and to provide sufficient evidence of the extent of the alleged losses. For example, the impact of the smoke plume from the oil fires on the health of the local populations, and the impacts of the oil spill on the habitat of the Persian Gulf could not be known without such studies. Technical experts, such as Dr. Aliahmad Korury , assisted each claimant Government in the conduct of its tasks to submit and substantiate claims, by ensuring the full development of the facts and relevant technical issues.

Dr. Aliahmad Korury was the project manager in charge of an important monitoring and assessment study in relation to environmental damage claims put forward by Iran. The purpose of the study was to trace oil and combusted oil-related contaminants in mangroves and other trees of impacted regions in Iran arising from Iraq's invasion and occupation of Kuwait through enzymatic stress

indicators. In this investigation, Dr. Aliahmad Korury provided the pre- and post-war evidence of the state of forest trees in the impacted regions through biochemical stress enzyme analysis.

Dr. Aliahmad Korury also attended and contributed to a number of meetings with the "F4" panel of Commissioners' expert consultants in Geneva and to site inspections in various locations in Iran.

In addition, she attended the hearings organized by the "F4" Panel of Commissioners at the Palais des Nations in Geneva for each instalment of environment claims and made significant presentations to the Panel on behalf of Iran.

In summary, I was impressed by Dr. Aliahmad Korury's technical expertise and objectivity, and her ability to translate her technical findings from the monitoring and assessment studies which she led to a coherent and concise report presented to the Commission to allow for a determination to be made on environmental damage. I found Dr. Aliahmad Korury to be a pleasant and knowledgeable professional to work with, and recommend her highly to you for consideration as an expert in her field.

United Nations Compensation Commission Commission de Compensation Nations Unies

Yours sincerely,

M. Kazazi

Mojtaba Kazazi
Chief, Governing Council Secretariat

Contents

Acknowledgments

I am grateful to three former Deputy Ministers. M. T. Amanpour (former Deputy Minister for Research and Education, Ministry of Jahad – e – Sazandegi) for awarding this research project to my group, Dr. B. Gharehyazi (former Deputy Minister for Research, Ministry of Jahad – e – Agriculture), and Dr A. Ahonmanesh (Deputy Research minister of Jahad – e – Agriculture). In addition, I would like to thank Dr. Adel Jalili, the former director of Research Institute of Forests and Rangelands (RIFR), for his support. I am also truly indebted to the many Master's and Ph.D. students who assisted in doing this project. I would like to give special thanks to all their helps and collaborations. They include: A. Ghassemzadeh, A. Hasani, M. Jahanshai, B. Jalilpour, N. Manouchehri, P. Motahedin, Y. Torabian and R. Zolfaghari.

Soudabeh Ali Ahmad Korori

Abstract

]

Persian Gulf War happened in January 1991 has distributed huge amounts of atmospheric pollutants in the Persian Gulf region. The pollution penetrated in one third of Iran's territory, atmosphere and water.

The recent research was carried out in five provinces (including Bushehr, Hormozgan, Sistan va Baloochestan, Chaharmahal va Bakhtiari, and Khuzestan) covering more than 25% of the area of Iran and also included limited parts of five other provinces (as Kurdistan, Lorestan, Kohkiluyeh -va- Boyerahmad, Fars and Illam provinces). Firstly, the ecological studies were performed to identify ecosystem characters. Then, the enzyme patterns were studied in 4 species (including *Avicennia marina, Prosopis cineraria, Quercus brantii* var. *persica, Ziziphus spina-christi*).

The number of sampled trees was as follows:

77 *Avicennia marina* individuals, 80 *Prosopis cineraria* individuals, 20 *Quercus brantii* var. *persica* individuals, and 80 *Ziziphus spina-christi* individuals, therefore 257 individuals were sampled in total.

Cross sections of branches were separated for enzyme analysis (peroxidase, amylase and catalase). Cross sections included years 1989 through 2001.Peroxidase and amylase were analyzed by polyacrylamide gel electrophoresis (PAGE) method qualitatively. Enzyme activities were determined by spectrophotometer methods .

Na, K, Ca, Cd, and Pb contents were measured after extraction, by means of atomic absorption; however S was estimated by turbidometric method. Two cross chores from all of the trees were taken for dendrochronological study.

In order to reinforce the main project (UNCC, 5000427), three complementary projects were also designed including *in-vitro*, anatomy and soil enzyme studies. The results of the main project showed the role of trees as a valuable indicator for different environmental stresses. Genetic diversity was high in all habitats except for Assaluyeh (Only two classes) by peroxidase method. Enzymes, the most sensitive stress indicators, showed abnormal alterations during the war year and the subsequent period (between 2 to 7 years). On the other hand, element analysis indicated uptakes of cadmium (Cd) and lead (Pb) during the mentioned period. In some individuals and regional indicators, K and Ca contents were increased. It seemed that their increases had a protective role against the pollution stress in trees as well. Enzymatic reactions depended on species and interspecies. Some trees were affected only in one year but others showed reaction over longer periods. Mangroves, oak and christ-thorn reacted with creating new patterns as well. Also some of the regional indicators showed abnormal patterns.

The amounts of pollutant elements assimilated confirmed the obtained results. Existence of black substances in tissues of mangrove and oak in 1991 was another reason confirming the effect of pollutions. The results have been also confirmed by dendrochronological studies. The decrease in annual growth rate was another important evidence showing the establishment of pollution as it showed physiological damages on plants tissues. In spite of high rate of annual precipitation in the war period (more than the average), there was a %35.65 decrease in the annual growth rate in all of the studied areas. Minimum and maximum decrease rates were observed in oak and

cashaw individuals, respectively. Soil analysis did not show any special pollution effects in different horizons, because the studies were carried out 7 to 8 years after war occurrence. Soil enzymes studies showed abnormal patterns in some areas such as Bordekhoun and Dayyer in different horizons.

In -vitro enzymatic results were consistent with the earlier results obtained in natural habitats. According to the results, pollution emitted through the war had affected total biological texture of the southern and western ecosystems of Iran. The results indicate that the existing organisms were affected by war pollution both directly (such as plant species) and indirectly (such as animals and human).

Qualitative results were classified to quantitative values to compare the rate of damages in the 12 studied locations. Relative amounts were calculated based on the different criteria such as physiological factors, growth rate, organic matter percentage, soil enzyme activities and plant enzyme reactions. The criteria could be divided into two main types. The first group is called negative parameters such as growth rate decrease, abnormal enzymatic reactions in soil and plant tissues, heavy metal and sulfur content that indicated instability of the ecosystem. The second group is called positive parameters such as organic matter, calcium and potassium content that indicated stability of the ecosystem. In order to calculate relative amounts, a range of values between 0-10 was determined for elements and percentage of organic matter. Enzymatic reactions and growth rate decrease being of importance, double value were selected for these factors in comparison to the others. The negatives were between 0-20 but the

positives had a reversed order. Therefore the highest and lowest positive parameters were given 0 and 20, respectively. On the other hand, the highest and lowest negative parameters had values of 20 and 0, respectively. Soil studies included five enzyme values (0, 2.5, 5, 7.5 and 10). This meant 0 for normal pattern in all of the enzymes, 2.5 for only one abnormal enzyme pattern, 5 for two abnormal patterns, 7.5 for three abnormal patterns and 10 for abnormal patterns within all of four studied enzymes. The final score was used as an indicator to compare different locations (shown in the Table). According to this classification, Kangan with the score of 7.3 and Assaluyeh with the score of 3.1 (both in Bushehr province) were the most sensitive and resistant ecosystems against Iraq- Kuwait war pollution effects, respectively.

Provinces	Locations	Stress physiology	Soil enzyme	Organic matter	Ca content	K content	Growth decrease	Cd content	Pb content	S content	Calculated rate
Bushehr	Asaluyeh	14.2	0	0	0	5.5	-	.95	2.9	1.65	3.15
Bushehr	Bordekhun	16.6	7.5	3.2	8	3	-	1.25	4.15	3.3	5.875
Bushehr	Dayyer	12.8	5	7.2	9.25	5.5	-	2.25	1.6	6.1	6.212
Bushehr	Saadabad	12.4	0	7.9	9	8	20	1.25	3.2	1.65	7.044
Bushehr	Kangan	19.5	2.5	3.2	9.75	8	192	.625	1.6	1.65	7.347
Khouzestan	Gotvand (Shushtar)	20	0	3.2	9	8.5	15.8	2.25	3.55	.55	7.205
Khouzestan	Bahmaii (Behbahan)	15.2	0	3.6	9.75	8	15.1	1.25	2.55	1.65	6.344
Hormozgan	Jalabi	12.4	2.5	7.4	6	7.5	11.3	.625	.3	10	6.447
Hormozgan	Kooleghan	13.4	5	5.2	6.5	8	-	.625	.3	8.735	5.97
Sistan & Baloochestan	Rasoolabad	7.4	0	5.2	7	4.5	9.8	5	1.3	8.3	5.388
Sistan va Baloochestan	Guatr	1.6	2.5	5.2	9.75	0	5.3	10	.6	1.65	4.066
Chaharmahal va Bakhtiari	Lordegan	8.6	0	5.2	9.5	3.5	12	4.8	10	5	6.511

Locations classification	Rates
Kangan	7.34
Shushtar	7.205
Saadabad	7.04
Lordegan	6.51
Hormozgan Pro	6.44
Behbahan	6.34
Dayyer	6.21
Hormozgan Avi	5.97
Bordekhun	5.875
Sistan-pro	5.388
Sistan-avi	4.06
Asaluyeh	3.15

According to the mentioned results, statistical analysis was carried out and a number of descriptive curves are presented in general discussion.

The results showed that enzyme activity in the war year (1991) decreased because of denaturation of the enzymes .Moreover, mean analysis of enzyme activity showed that there were significant differences between the amounts in 1991 and the average amount of all years after. All the three enzymes (peroxidase, catalase and amylase) showed a high consumption in 1991 in comparison with the average of the years later. The results proved peroxidase to be the most sensitive enzyme to the pollution as compared with the other enzymes.

Moreover, scatter plot of heavy metals (1:1 diagram) showed accumulation of these substances within plants tissues. Results indicated that lead (Pb) concentrations were more than cadmium (Cd) and sulfur (S) in 1991 (after war beginning) in comparison with the year 1988 (before war) (Aminipouri 1999, Korori 1998,). In three studied species growth rate decreased rather in the 1991 than the average of the other years whereas the amount of precipitation in the former year was more than the annual mean of the regions. The

highest reduced growth rate was seen in Cashaw in Kangan location (in Bushehr province). The higher diameter classes of trees showed more decrease rate than the lower ones.

To summarize, the results emphasized on the effects of war pollution on the biological texture (plants and soils) of the different ecosystems in the south and southwest of Iran. The most polluted region was determined to be Bushehr province and the most sensitive species appeared to be *Prosopis cineraria.*

High recovery ability was seen in reserved ecosystems after the pollution effects. The results indicated trees as the important bioindicators against the pollution effects and other ecological stresses and peroxidase as the most sensitive enzyme in ecological studies.

In order to generalize the results to all of the forest trees, rangeland and medicinal plants, *in-vitro* studies were performed on other species (*Amygdalus scoparia*, *Periploca aphylla*, *Artemisia sieberi* and *Tecomella grandis*). The results indicated that these species reacted to stress and some of them reacted with new patterns against pollution uptake, like the reaction to Pb (NO_3) 2 treatments.

In order to simulate the plants reactions in natural condition against pollution effects, *in-vitro* studies were also done. Our findings demonstrated that trees could be used as important bio-indicators. These results showed a great conformity with those of main experiments in the field.

Finally, total values of forest damaged in the Zagrossian and Khalij-e-omani region of Iran calculated.

1. Introduction

Following Persian Gulf War occurred in January 1991, huge amounts of atmospheric pollutants were distributed in the Persian Gulf region. Atmospheric and water pollutants penetrated into one third of Iran's territory as a consequence of the war (Aminipouri 1999).

Research conducted by international agencies and regional and national institutes revealed the extensive distribution of smoke and soot over the Persian Gulf and surrounding countries. Reports of atmospheric pollutants reaching Turkey, Syria and as far as India and Himalayas were frequent. According to SCWMRC reports, based on analysis and processing of about 1267 NOAA AVHRR satellite pictures, about 35% of the total atmospheric pollutants were resulted from the burning of one billion barrels of Kuwait oil had penetrated into Iran's territory (Aminipouri 1999). The research done in 1991 by Esmaili–Sari and Zare–Maivan indicated that the terrestrial deposition of these pollutants covered approximately one third of Iran's territory. Wet deposition of pollutants occurred as black rain in plains and lowlands and black snow in mountains. Moreover with regard to wind effect, a great deal of air pollutants were transferred to different regions of Iran even in central locations (such as Tehran) and south-east of Iran (Sistan va Baluchestan province). Additionally, in the Persian Gulf and Oman Sea area (mangrove and other trees habitats) received oil and other pollutions (Korori 1998).

Substantive claims of the Ministry of Jihad-e-Agriculture (MJA), were registered as claim No.5000456 (5000288) before the UNCC, via an F4 category claim. MJA claims seek compensation for damages, for clean up costs, ecological economic losses, remediation and

restoration costs as a result of depletion of natural resources and degradation of environmental attributes following the extensive and prolonged introduction of atmospheric pollutants and spilled oil into the territories and marine environments of Iran in 1991(Aminipouri 1999).

Claims of losses to natural resources of soil and water, forests, agricultural lands, rangelands, wetlands, coastal and inertial and sub tidal ecosystems, fisheries and livestock were among damage elements included in the MJA substantive claim No.5000456. In reviewing text of relevant Exhibits annexed to the MJA claims, one finds out that there are several key points effectively contributing to variations in the amount of claims sought for. Some of these points may relate to scientific approaches in connecting pollutants to the source of about 700 burning Kuwait oil wells and damaged oil terminals; some other points may relate to methodology of damage assessment in affected areas in comparison to pre – 1991 war status and tracking and monitoring of ecological attributes over time and data processing; and still others may deal with methodology applied to calculate qualitative or quantitative data into monetary values put forward in the claim(Aminipouri 1999, korori 1998).

This project was carried out 7 years after Persian Gulf War damages. In order to prove the influence of war on natural ecosystems, a method was designed which was able to compare the condition of war period with periods before and after.

Trees were used as indicators because of having annual growth rings. Enzymes, cation and anion variations were analyzed in plant textures.

At the preliminary stage, the director of the project suggested about 41 locations in 11 provinces where black rainfall had been reported. In the first schedule, 4 years and 10 replicates per species per location were predicted. But based on UNCC scientific consultant suggestions, the study period was limited and number of replicates were increased to 20-40 individuals per species per location. Dendrochronological studies were added to the project, as well.

Therefore sampling areas were limited to 5 provinces. Study locations included 5 provinces: Chaharmahl VA . Bakhtiari, Khouzestan, Boushehr, Hormozgan and Sistan va Baloochestan and studied species included *Avicennia marina, Ziziphus spina-christi, Quercus brantii* var *persica* and *Prosopis cineraria.* The second group included Kurdistan, Lorestan, and Kohkiluyeh -va- Boyerahmad, Fars and Illam provinces.

Three complementary projects were carried out including soil enzyme studies, anatomical studies together with *in-vitro* studies related to the establishment of pollution effects on the ecosystem .

Some soil biological phases were conducted (vertical biological gradient and comparison studies) by means of soil enzymes variations.

Anatomical studies were done to determine the levels of pollution uptake in *Avicennia marina, Ziziphus spina-christi, Quercus brantii* var. *persica* and *Prosopis cineraria.*

An *in-vitro* model was designed in order to eliminate unrelated pollution factors and natural stresses and studied species included 1- *Amygdalus scoparia* as a mountainous species in the southern regions of Iran, 2- *Tecomella undulata* as a reserved species, *3- Periploca aphylla* as a widespread species in the southern regions of Iran and *4-*

Artemisia scoparia as a widespread rangeland species in all Iran's territory.

The British biochemist, Dixon has described living matter as a system of unstable catalysts being kept in existence by the occurrence of the reaction, which they catalyze. This implies that the ratio of catabolic to anabolic enzymes increases or decreases concerns to age, genetic and ecological alterations (Ebegt 1977).

As a matter of fact, peroxidase shows the highest reaction to environmental stress (Castillo 1992) and therefore the role of trees as an important indicator of stress occurring has been demonstrated (Castilo 1990 , Ebermann 1991).

Sulfur dioxide (S_{O2}) is one of the major byproducts of burning oil. It has been proven that S_{O2} changes into sulfuric acid in the air and sulfuric acid is capable of causing permanent damage to leaves and stems of plants (Pfanz 1991). Our studies and those of others, during the past 20 years, have showed that specific changes in the enzymes of the plants occur as a result of environmental stresses (Castillo 1992 ,Castilo 1990).

Plants absorb high levels of heavy metals from the soil and subsequently enter the bio-system. Research conducted at British universities has shown that increased concentration of zinc and copper affects the activity of the phosphatase. The same elements along with cadmium and lead affect the activity of amylase in conifers (Ebegt 1977, Mellanby 1988).

Plant species respond to environmental pollution in different ways. Enzymes are the most important indicators in plants for environmental stress monitoring and peroxidase is one of the most sensitive enzymes

for the study of the ecological transitions (Castillo 1992, Castilo 1990, Ebermann 1991). Plants, especially trees, have an important role in monitoring environmental alteration. The level of the enzyme decreases from cambium towards the pith of trees. On the other hand, the higher amount of cambium content leads to more activity of extracts (Ebermann 1982).

Dendrochronology is the dating of past events through the study of growth rings in trees. A.E. Douglass first used this technique in 1920 in his dating of Pueblo Bonito, a prehistoric American settlement in New Mexico (Shroder 1975). Dendrochronology is critical to solve many environmental problems. Ring analysis is used in a variety of ways to diagnose pollution effects in their early stages. Dendrochronology is used to predict or manage environmental conditions in the future. It is useful in diagnosing pollution, adjusting irrigation projects and in recalibrating C^{14} process. Karlsson (2001) showed the effect of environmental factors such as drought, infestations and pollution on the radial increment of Scots pine on sandy soil in western Finland. Tree rings are used as an indicator of ecosystem health.

Soil is a living system most of whose biochemical activities proceed through enzymatic reactions. Enzymes are bio-products that accumulated in soil organisms in different forms. They are very important in the modification of organic matter and show the quantity of life levels in soil systems (Dick 2000, Gershuny 1995).

Enzyme activities in the soil of an undisturbed ecosystem are higher than those of manipulated ecosystems (Dick 2000, Sachs 1999).

According to the above antecedent, a comprehensive project was designed to monitor pollution effects on biological structures in southern and central parts of Iran.

1.1. Study sites:

Ecology and socioeconomic importance of affected regions

Khalij –o -Ommani region

Having a forest area of 2880000 km^2, this area was a sub-region of Sahar-o-Sindian covering four provinces. There are many important plant species including *Dalbergia sissoo, Acacia albida, Moringa perregrinea, Tecomella undulata.* The number of plant species in this region is 1030 with more than 200 tree and shrub species. The population of the area is 6,931,620. In total, Zagross and Khalij –o -Omani forests compromise about 60 % of Iran's forest.

Figure 1- Forest ecosystem, a landscape in Khuzestan province