Response of Calotropis Procera for Urban, Suburban and Sewage Pollution

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استجابة نبات العشار لتلوث المدن والضواحي والتلوث الناتج عن الصرف الصحي

تم جمع عينات من النبات البري المعروف بالعشار من أماكن عديدة من مدينة مكة المكرمة بالمملكة العربية السعودية. وقد تم جمع العينات من مناطق داخل المنطقة المركزية ومن مناطق أخرى في ضواحي المدينة. وتم جمع مجموعة ثالثة من العينات من جوار محطة معالجة الصرف الصحي للمدينة. تم تطبيق طريقة تحليل الحث الإشعاعي للنيوترونات آليا في تحليل العينات بهذا العمل. تم دراسة وتحديد ورصد التراكيز لعناصر البروم، والمغنسيوم، والصوديوم، والبوتاسيوم، والكلور، والكالسيوم، والكوبالت، والزنك، والحديد، والروبيديوم، والسيلينيوم، والاسكانديوم والكروم لجميع العينات من المدينة والضواحي. كما تم تحديد ومقارنة ورصد التراكيز للعناصر السابقة للعينات المجمعة من جوار محطة معالجة الصرف الصحي بالتراكيز المحسوبة لعينات عياريه. وتم أيضا مناقشة الفروق الناتجة عن تعرض العينات المختلفة للملوثات من العناصر المختلفة.

Abstract

Samples of the wild plant of *Calotropis procera* were collected from the urban area of the Holy City of Makkah in the Kingdom of Saudi Arabia. The collection was taken from areas within the town centre as well as from suburban areas. A third set of samples was collected from nearby the sewage treatment plant of the city. Instrumental neutron activation analysis was the analytical method employed in this work. Elemental concentrations of Br, Mg, Na, K, Mn, Cl, Ca, Co, Zn, Fe, Rb, Se, Sc, and Cr were investigated and reported for all sets of samples. Concentrations of the above elements in samples from the urban areas and those from the suburban areas were compared to controls and reported. Concentrations of the above elements in samples collected from the nearby the sewage treatment plant of the city were compared to controls and also reported. Variations in concentration values resulting from sample exposure to polluting elements and sample location were discussed.

Keywords: Calotropis procera**,** sewage, pollution, INAA, elemental concentrations, environment.

INTRODUCTION

Plants have been known as good indicators for air and soil quality. Pollutants usually affect plants as they are introduced into the plant via deposited contaminants in the soil or via ingestion through leaves. Sources of pollution can be industrial, vehicular traffic, heavy population and hence household, sanitary and human wastes.

The response of plants to contamination can be manifested as an increase in the uptake of elements when the effect of pollution is minor. Increased introduction of foreign elements to the plant or excessive presence of some essential and trace elements can result in the toxicity of the plant and hence change of leaves colour, inhibition to the germination and growth of seeds or even death of the plant may be evident (Abbasi *et al.* 1992). Other effects of pollution can be described as inhibitory effects, by the fact that the excessive presence of some elements can result in blocking the uptake of other elements, and hence depriving the plant from absorbing essential elements from the soil (Altaf 1997).

In addition, it has been noted that the type of soil can play an important role in the uptake of elements by the plant in right amounts. Rich soils in minerals, however, have less tolerance to pollutants which can consequently destroy the plant, depending on the plant species and the type of soil in which the plant grows.

Urban pollution is mainly referred to, as the gaseous substances that are released to the atmosphere causing deterioration in the air quality. Vehicular traffic is known as the major cause of this type of pollution. Household solid refuse is one of the polluting sources but as it is controlled and dumped in the proper way it may not contribute to ambient pollutants and hence does not affect air quality.

Suburban pollution is usually a combination of the vehicular traffic and industrial releases of gaseous substances. It is usually less severe than urban pollution as heavy traffic and the driving patterns in towns and congested areas result in the production of hydrocarbons plus sulphur, lead and other pollutants more than found in suburban driving.

Sewage if not properly controlled and disposed of, can be considered as a serious source of pollution and contamination to the environment. It can adversely affect human health, plants and living creatures. Sewage treatment plants are usually designed to reduce the effect of sludge and row sewage on the environment. Some treatment plants tend to fully treat sewage and separate the recyclable water for further use. Other plants treat sewage partially as to retain the sludge and solid waste and then releases the filtered water in open pathways to the environment and let the environment treat this water. The released water in this case will be part of the ecological system and hence its effect will be reflected upon wild life and plants.

The sewage treatment plant referred to in this study is of the second type mentioned above. The sludge and solids filtered water runs out of the treatment plant in a canal that reaches 4m in width and stretches in the desert for over 30km, leaving around its pathways different species of plants irrigated by this water and attracting migrating birds and transforming what, used to be arid land to rich in plants and wild life. However the quality of the plants is not to be thought of as good because of the poor quality of that irrigation water which can be judged by its bad smell.

Plants therefore respond to variations in the elements they are exposed to via air or solid deposition, and may be indicative of some of these variations. Clotropis procera plant investigated in this work has proved in the past that it has a good response to foreign elements, especially from pollution resulting from vehicular traffic (Altaf 1997). The importance of this plant to this study comes from the that this plant is abundantly found in the locations aimed by this study, besides the fact that it is not edible and therefore no disturbance of the plant can take place whether by man or animals.

EXPERIMENTAL

Calotropis Plant

Calotropis procera is an ascending to erect shrub with large, broad fleshy pale green leaves. Leaves can grow to up to 200mm in length and 150 mm in breadth. The bark of the shrub is corky and brittle. It reaches up to 5 meters in height. It produces milk when cut across leaves or young branches. It is green throughout the year and best in spring. The plant is poisonous, however, minute quantities of its extracted milk is known to have remedial properties in traditional and Greek medicines (Migahid 1996). In this study, leaves of the plants were the only organ investigated.

Sample Collection

All the samples of this study were collected from the holy city of Makkah and its suburbs. The city has about two million inhabitants, and has a good sewage disposal network.

Samples of green leaves of Calotropis procera were extracted from green branches at a height of 1.5m above the base of the tree to minimise the inconsistencies arising from absorption of nutrients and osmosis. Each sample consists of 9 leaves and samples were collected from the locations as follows:

1- 10 samples were collected from each of four different locations as close as the plant is found to the centre of the city . These samples are referred to as the urban samples.

2- 20 samples collected from each of 10 locations out of the city at an approximate radius of 15km from the city centre. These samples are referred to as suburban samples.
3- 20 samples were collected from plants found along the banks of the sanitary water pathway which looks very much like a canal and runs out of the sewage processing plant and away for about 30km. These samples are referred to in this work as the sewage water irrigated samples (swis).
4- 30 samples were collected from a rural area 40km away from the city limits. The location is free from city or highway pollution and not even reachable by normal cars. These samples are treated and referred to as controls.

Sample preparation

All samples were initially washed with tap water to remove dust and other residues from the surface of leaves, then leaves were immediately cleansed using deionised distilled water and left to dry for 14 days in a laminar flow hood in a clean room environment. The samples were then crushed to powder using a ceramic mortar, and kept in polyethylene containers.

In this study, the powder samples from each area were added up in equal quantities and homogenised to be representative to the area they were collected from. Prior to irradiation a sample mass of approximately 120 mg (dry weight) was palletised using a 7mm die. Then, each samples was encapsulated mainly in polyethylene containers, the size of which varied according to the irradiation system of the reactor employed in this work. 10 samples from each location were made ready for irradiation.

Analytical Technique

Instrumental neutron activation analysis INAA using reactor neutrons was the technique employed in obtaining the elemental concentrations of all elements investigated in this work. The comparative method, using Bowen's kale and IAEA-Soil-7 reference materials as comparators, was applied for all samples. All irradiations were carried out at the Imperial College Reactor Centre in their Consort II reactor in two main systems.
Sample irradiation and counting took place in three different stages using conventional irradiation. Two reactor irradiation positions were employed (O'Connell 1994):

1-The in-core irradiation system, ICIS, which enables samples to be irradiated for short periods from one minute to one hour in a thermal neutron flux of $2.29 x 10^{12}$ n cm^{-2} s^{-1} The irradiation conditions used in this system were 60s irradiation, 120s cooling and 300s counting. The mass of sample irradiated under these conditions was around 120mg. This set of irradiation conditions allowed the detection of Br, Cl, Ca, K, Mn and Na .

2-The core tube irradiation facility, CT, which enables the sample to be irradiated for long periods of time, ranging from 7 hours to several weeks, according to sample type and properties. Activation of the long lived nuclides in the samples was performed in two sets of irradiation and counting conditions. The first of which is 7h irradiation, 48h cooling and 1h counting. The second set was 71h irradiation, 240h cooling and 1.5h counting. These last two sets of irradiation conditions allowed the detection of Mg, Cr, Rb, Se, Sc Fe, Co and Zn.

The detection system comprised a Ge(Li) detector in conjunction with an EG&G Ortec data acquisition system.

RESULTS AND DISCUSSION

Concentrations of 14 elements detected in the plant in the urban and the suburban areas of Makkah are presented in table 1. For samples collected from the vicinity of the sewage treatment plant the concentration values are presented in table 2. Values exhibited in table 1 indicate variations in the concentrations of Br, Mn, Se, Cr, Fe and Zn in the urban and the suburban samples when compared to those in controls. Of particular interest, Br concentrations were found to be more than 7 times greater in the urban samples than either of the suburban and controls which may suggest that city pollution had contributed greatly to the Br uptake of the plant. Mn and Zn were also higher in urban samples. These findings agree with previous studies on the effect of traffic emissions of motorways on road-side plants and a study on road-side suspended air particulates (Altaf 1997 and Ogunsola *et al.* 1993). Se concentration was slightly higher in urban samples and getting lower in suburban samples and even lower in controls. On the contrary, Fe concentrations exhibited low values in urban samples, higher in suburban samples and much higher in controls.

Values for samples collected from the vicinity of the sewage processing plant also exhibited low Fe concentrations compared to controls. This is consistent with the previous study of motorway pollution that suggests that an adverse effect of pollution may have resulted in lower uptake of Fe by the plant (Altaf 1997). Sewage samples also indicated high levels Mn and Cr which may attributed to the contamination of the water released from the processing plant. The low levels of Na and Sc may be due to the leach out of their salts from the plant due to their exposure to excessive amounts of water. A study by Eriksson suggests that elements and minerals can be leached out when excessively exposed to sewage water (Eriksson 2001). In addition, leaching of salts takes place as the water uptake is high resulting in dissolving the salts faster preventing it from undergoing a complete metabolism (Migahid 1996).

Figure 1 illustrates the elemental concentrations of the studied elements classified according to the category of location.

CONCLUSIONS

Calotropis procera can be a useful botanical monitor of pollution. The variations found in the concentrations of Br, Mn, Se, Cr and Zn between urban and suburban samples suggests that the plant has a good potential for the determination of these elements when it is exposed to them from any source. Br, Mn and Zn concentrations in the plant were found greater in the urban area than in controls which emphasizes the assumption that they are resulting from traffic pollution.

The low concentration of some elements in the sewage samples may be attributed to the leach out of salts from the plant due to their exposure to excessive amounts of water. Hence, plants can lose mineral content due to excessive irrigation.

The sewage water release from the sewage processing plant did not severely affect the plants or their growth. However contamination of the plant occurred although it was not fatal.

This study may prove that using plants for monitoring pollution is an adequate way as the availability of plants throughout the years can give good information and good history of the quality of the environment. However, further study is needed using other complimentary techniques for extensive determination of elemental presence in these plants. In addition, chemistry studies are required for water and fluids analyses in order to work out studies of antagonistic effects and correlation of the chemical compounds of the plant and its source of irrigation.

	Urban		Suburban		Controls	
Element	Mean conc. (mg/kg)	SD (%)	Mean conc. (mg/kg)	SD (%)	Mean conc. (mg/kg)	SD (%)
Br	490	29	57	18	67	6
Mg	8600	14	9900	11	8100	5
Na	3500	78	3500	76	5960	62
K	33000	31	50600	28	34500	3
Mn	82	13	63	5	32	2
Cl	15600	11	21000	13	15100	5
Ca	15400	19	15800	21	12400	7
Se	0.11	21	0.08	16	0.06	18
Cr	0.82	13	1.77	11	ND	
Sc	0.006	42	0.014	38	0.011	25
Rb	6.58	17	2.856	14	6.44	11
Fe	55	12	77	16	300	22
Zn	76	9	16.07	11	46.0	6
Co	0.85	17	0.72	14	0.75	12

Table (1): Concentrations of elements detected in *Calotropis procera* in urban and suburban Makkah
ND: not detected

	Samples		Controls	
Element	Mean conc. (mg/kg)	SD (%)	Mean conc. (mg/kg)	SD (%)
Br	51	18	67	6
Mg	9600	17	8100	5
Na	2700	33	5960	62
K	34200	19	34500	3
Mn	155	8	32	2
Cl	16800	11	15100	5
Ca	13700	13	12400	7
Se	0.033	11	0.06	18
Cr	0.514	16	ND	
Sc	0.0037	31	0.011	25
Rb	4.04	15	6.44	11
Fe	66.4	18	300.0	22
Zn	38.89	10	46.0	6
Co	0.81	15	0.75	12

Table (2):Concentrations of elements detected in *Calotropis procera* in the in the vicinity of the sewage processing plant.
ND: not detected.

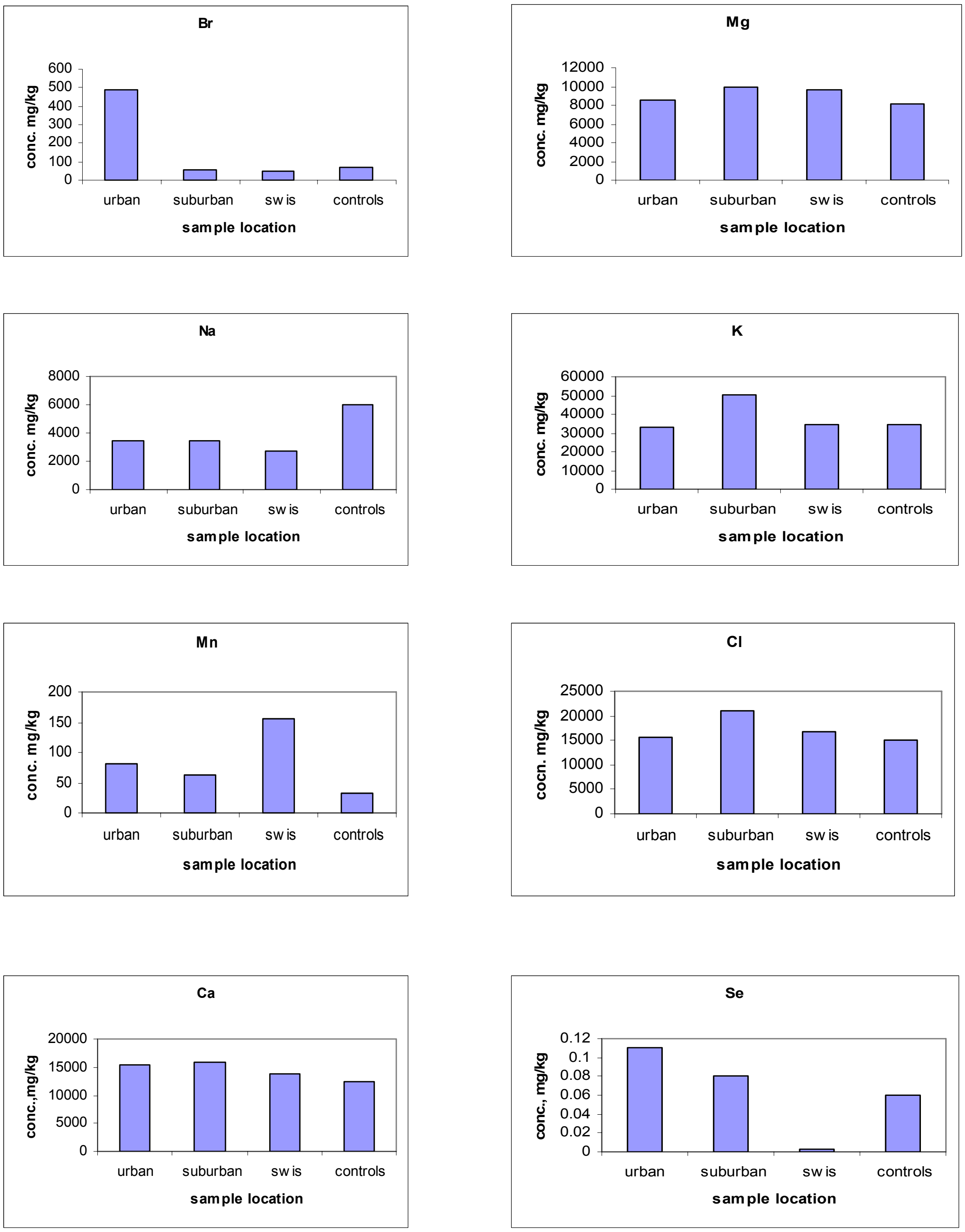

Figure (1): Concentrations of Br, Mg, Na, K, Mn, Cl, Ca and Se in urban, suburban and swis samples

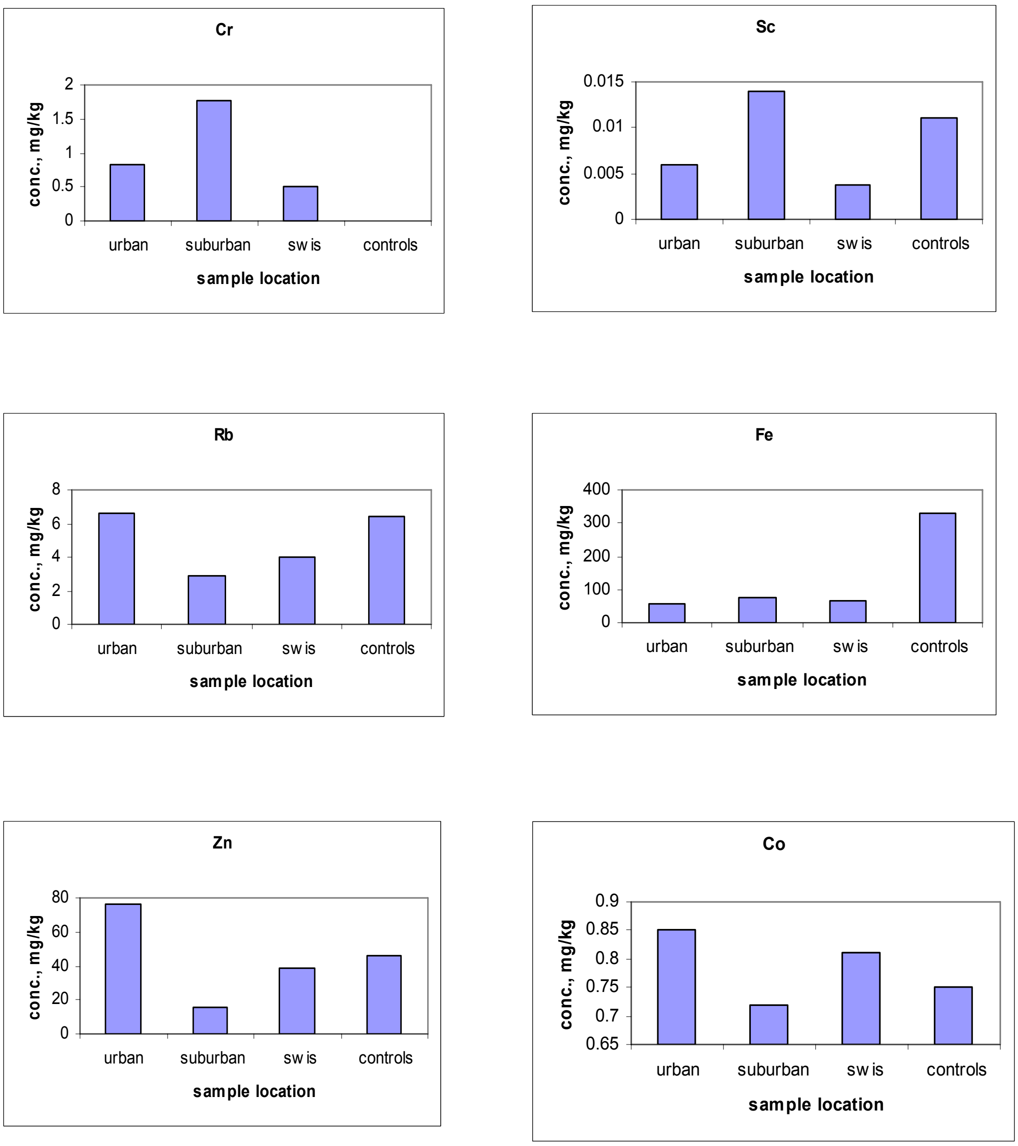

Figure (1): (continued) Concentrations of Cr, Sc, Rb, Fe, Zn and Co in urban, suburban and swis samples

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