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A Class of Algorithms for Zeros of Polynomials

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Abstract. A class of polytype algorithms for the determination of zeros of polynomial equation of single variable was constructed from Jarratt’s asymptotic error constant using the well-known Chebyshev’s comparison series. The method was synthesized from the Taylor series iterative method. The climax of the findings was that the proposed formula can effectively model the determination of zeros of polynomial equations of the type often encountered in the Givens orthogonal matrix transformation process.

Keywords: polynomial zeros, Jarratt’s asymptotic error constant, Taylor series, Laguerre iterative method, Givens orthogonal matrix transformation

Introduction
The aim was to solve a non-linear operator equation, \( p(z) = 0 \), by an iteration that builds up a sequence of approximation \( \{ z_i \} \) iteratively, where it was assumed that \( p \) is sufficiently smooth in its domain of definition. Laguerre’s method is an iterative operator which uses non-linear information, the degree of the polynomial whose root was being sought. Thus, there exist two widely circulated iterative operators for approximating roots of non-linear equations, namely, the stationary and non-stationary methods, respectively.

The stationary iteration is one-point iteration operator without memory. This means that it is independent on previously calculated values, unlike the case of the Secant method, as well as the Steffensen iteration, which are the members of non-stationary iteration and are regarded as multipoint stationary iteration operators with memory. To motivate further interest in this, the same reasoning as of Wasilkowski (1980) was applied in the case of non-stationary iterative operator. This paper, as a result, develops a class of polytype algorithms derived from the Taylor series iterative formula using Jarratt’s asymptotic error constant (Jarratt, 1968) for the determination of zeros of polynomial equation obtained from the Givens orthogonal matrix plane rotation (Wilkinson, 1965). For easy orientation, the Taylor series expansion for \( p(z) \), about the \( z = z_i \), has been defined as follows:

\[
p(z) = p(z_i) + p'(z_i)(z - z_i) + \frac{p''(z_i)}{2!} (z - z_i)^2 + \sum_{j=3}^{\infty} \frac{p^{(j)}(z_i)}{j!} (z - z_i)^j
\]  

(1.1)

If it is set as \( p(z) = 0 \) and take cognizance of the fact that \( z_i^{(k)} \in z_i (k = 0, 1, ...) \), then the Taylor polynomial would be in the form:

\[
0 = p(z_i^{(k)}) + p'(z_i^{(k)})(z - z_i^{(k)}) + \frac{p''(z_i^{(k)})}{2!} (z - z_i^{(k)})^2 + \frac{p'''(z_i^{(k)})}{3!} (z - z_i^{(k)})^3 + \sum_{j=4}^{\infty} \frac{p^{(j)}(z_i^{(k)})}{j!} (z - z_i^{(k)})^j
\]  

(1.2)

because:

\[
z_i, z_i^{(k)} \in z_i^{(k+1)} - z_i^{(k)}, \text{ so that in the limit } \zeta \in z_i
\]

where:

\[
\zeta (i = 1, 2...n) \text{ in the case of simple zeros, approximate sufficiently close to the zeros of } p(z), \text{ then it would be:}
\]

\[
\zeta = \frac{z_i^{(k+1)}}{p'(z_i^{(k)})} \left[ p(z_i^{(k)}) + \sum_{m=2}^{\infty} \frac{p^{(m)}(z_i^{(k)})}{m!} \right] \quad \cap z_i^{(k)}
\]  

(1.3)

In view of method (1.3), the nested sequence would be:

\[
z_i^{(k)} \supset z_i^{(k+1)} \supset ... \supset z_i^{(n)}
\]

Neglecting the terms higher than second order derivatives in method (1.3), a convergent iterative method with non-intersection property can be obtained:

\[
z_i^{(k+1)} = \frac{1}{p'(z_i^{(k)})} \left[ p(z_i^{(k)}) + \frac{p''(z_i^{(k)})}{2} (z_i^{(k)} - z_i^{(k)})^2 \right] \cap z_i^{(k)}
\]  

(1.4)

where:

\[
z_i^{(k+1)} = \left[ \frac{z_i^{(k)} + p(z_i^{(k)})}{p'(z_i^{(k)})} \right] \cap z_i^{(k)}
\]  

(1.5)

The foregoing is a preliminary discussion for deriving non-stationary iterative operator for the solution of zeros of poly-
The Nature of Aquifers in the Crystalline Basement Rocks of Ado-Ekiti, Igede-Ekiti and Igbara-Odo Areas, Southwestern Nigeria

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Abstract. Geoelectrical investigations (vertical electric sounding, VES) for groundwater in the basement rocks of Ado-Ekiti, Igede-Ekiti and Igbara-Odo areas, Southwestern Nigeria were carried out. Geophysical data revealed the area as the one that has undergone an irregular weathering front. The geoelectric curves at VES 1, VES 2 and VES 3 at Igbara-Odo were classified as HA, HAA and KH, respectively, while the two VES stations at Ado-Ekiti produced Q and KQH type curve. At Igede-Ekiti, the geoelectric curves obtained for the three VES stations were KH, KQHK and KHKH types. The VES stations were located in a migmatite-gneissic terrain at Igede-Ekiti, gneissic charnockite at Ado-Ekiti and in a granite-gneiss migmatite country rock at Igbara-Odo. Geoelectric layers varied from 3 at Ado-Ekiti to 6 at Igede-Ekiti, with probed thicknesses of between 0.7 m to 151.9 m. The results of the processed data suggested that aquifers occurred both in the regolith and the fractured bedrock. In places, a regolith and the underlying saturated fractured bedrock might constitute the aquifers, having the promise of siting high yielding boreholes, such as at Igede-Ekiti and Igbara-Odo. However, thickness and recharge problems made siting a borehole at Ado-Ekiti VES stations undersirable.

Keywords: aquifer, regolith, groundwater, water recharge, geoelectrical method, Southwestern Nigeria, vertical electric sounding

Introduction

Three prominent towns in Southwestern Nigeria, Ado-Ekiti, Igede-Ekiti and Igbara-Odo were investigated geophysically for their underground water potential. These towns lie within the basement complex terrain in Southwestern Nigeria. This study area is a part of the extensive Yorubaland Plateau which stretches from the Niger Trough in the North to the Yoruba lowlands of the Southwestern Nigeria in the South. The elevation varies between 200 m and 500 m above mean sea level. Prominent hilly features include inselbergs, whalebacks and other categories of residual hills which are commonly associated with massive granite bodies (Olarewaju, 1981). The area of study was within latitudes 7°20′ N and 7°41′ N and longitudes 5°6′ E and 5°20′ E (Fig. 1), which receives tropical rainfall from March to November with a short spell of dry season in December to February. There may occur sporadic rainfall during the short dry season. The study area has a tropical climate with a mean annual rainfall of 1,500 mm. Major rivers which drain the area include Rivers Elemi, Ureje and Ogbese, which together with their tributaries act as sources of recharge, apart from the direct infiltration of rain into the ground. The mean groundwater recharge from the rivers is about 250 mm, while rainfall infiltration accounts for a much higher amount of about 1,000 mm (DMS, 1999). The heavy rainfall is responsible for myriads of seasonal streams which drain the area of study giving a somewhat dendritic drainage pattern. Tropical weathering and erosion affect the basement rocks of the Southwestern Nigeria. The rocks in the area studied, similar to other rocks in the basement complex of Southwestern Nigeria, have undergone polycyclic metamorphic deformation leading to folding, foliation, faulting and fracturing. In the basement complex of the study area, both the regolith and fractured bedrocks have been described as the aquifers for groundwater from where it has been described as being structurally controlled (Clark, 1985). Other workers have described aquifers that are situated in the non-transported weathered overburden of crystalline rocks in the basement complex (Ajayi and Abegunrin, 1990; Alagbe and Raji, 1990). Jones (1985) concluded that the regolith overlying the fractured bedrock often provides the aquifer for groundwater in the basement complex terrain.

Despite the abundant and regular rainfall, associated with consequent surface water abundance in the area of study, the potable water supply is grossly inadequate constituting a recurring social problem. Surprisingly, the problem of shortage of potable water supply is not restricted to the developing world alone. Recently, Falconer (2003) described water as one of the world’s most precious resources, concluding that urbanisation presents increasing challenges of how to ensure adequate water supplies and a suitable water environment for future generations worldwide. In the present study,

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Studies on Ion-Solvent and Ion-Ion Interactions and Adiabatic Compressibilities of Some Bromide Salts in Methanol at Different Temperatures

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Abstract. The densities, viscosities and ultrasonic speeds of some tetraalkyl and monovalent electrolytes, such as tetraethylammonium bromide, tetrapropylammonium bromide, tetrabutylammonium bromide, lithium bromide, sodium bromide and ammonium bromide, have been determined in methanol at 303, 308, 313, 318 and 323 K. The limiting apparent molar volumes ($V_\phi$) and experimental slopes ($S_v$), supplemented with density data, have been interpreted in terms of solute-solvent and solute-solute interactions, respectively. The parameters B and A, obtained from the viscosity data analyzed using the Jones-Dole equation, have also been interpreted in terms of solute-solute and solute-solvent interactions, respectively. The results show that these electrolytes have structure-making capacities in this solvent. The compressibility data supplemented with the ultrasonic speeds explain the electrostriction of the solvent molecules around the positive ions.

Keywords: solute-solvent interaction, solute-solute interaction, adiabatic compressibility, structure-making capacities, electrostriction, apparent molar volumes

Introduction

Studies on the thermodynamics, transport properties, and ultrasonic speeds of different electrolytes in different solvents are of great importance to obtain information on the behaviour of ions in solutions. Recent years have, therefore, witnessed increased interest in this topic, as is evident from numerous publications in this field (Roy and Jha, 2001; Roy, 2000; Janz, 1973). In the present work, an attempt has been made to provide an unequivocal interpretation of solute-solvent and solute-solute interactions, and adiabatic compressibilities for some tetraalkylammonium and alkali metal bromides in methanol through the measurements of their densities, viscosities and ultrasonic speeds at various temperatures. Methanol is a protic solvent, which is known to be extensively self-associated through hydrogen bonding in the pure state (Pikkarainen, 1988). The importance of this solvent lies in the fact that it has found its applications in many industrial processes and also as a solvent medium for various electrochemical investigations (Das and Hazra, 1995).

Materials and Methods

Methanol (E. Merck, India, Uvasol grade 99.5% pure) was dried over 3 Å molecular sieves and distilled fractionally. The middle fraction was collected and redistilled. The purified solvent had a density of 0.78140 g/cm$^3$ and a viscosity of 0.51105 cp at 303 K. These values agreed well with the values reported in literature (Saha and Hazra, 1995; Doe et al., 1990). The purities, as checked by gas chromatography, were found to be 99.8% for methanol. Tetraalkylammonium bromides were of purum or puriss grade (Fluka) and were further purified as described earlier (Muhuri and Hazra, 1996). Lithium, sodium and ammonium bromides were of purum or puriss grade and were further purified as described earlier (Roy et al., 1993a). A stock solution for each salt was prepared by mass and the working solutions were obtained by mass dilution. The conversion of molality into molarity was done using the density values (Shoemaker and Garland, 1967).

The densities ($\rho$) were measured with an Oswald Sprengel type pycnometer having a bulb volume of 25 cm$^3$ and an internal dia of the capillary of about 0.1 cm. The pycnometer was calibrated at (303, 313 and 323 K) with double distilled water and benzene. The pycnometer was equilibrated with the test solution in a waterbath maintained at $\pm$0.01K of the desired temperature by means of a mercury -in- glass thermoregulator and the temperature was determined by a calibrated thermometer and Muller bridge. The pycnometer was then removed from the thermostatic bath, properly dried and weighed. The evaporation losses remained insignificant during the time of actual measurements. The average of triplicate measurements was taken into account. The density values were reproducible to $\pm$3 x 10$^{-3}$ g/cm$^3$. Details have been discussed earlier (Nikam and Hasan, 1988).
Viscometric Study of Interactions of Poly(Vinyl Alcohol) with Different Solvents at Various Temperatures

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Abstract. Viscosities of poly(vinyl alcohol) in aqueous-methanol system (10% to 50%, v/v) and aqueous-butanol system (1% to 5%, v/v) were measured at different temperatures (25 to 45 ± 0.1 °C) with different concentrations of poly(vinyl alcohol) ranging between 3.0 to 9.0 g/l. Solute-solvent interactions were found affected by changes in the compositions of solvents and the temperature. Various thermodynamic parameters were determined by the change in viscosity data as a function of temperature. It was observed that the free energy change of activation (ΔG*) increased regularly as the concentration of poly(vinyl alcohol) increased, but the effect with rise in temperature was uncertain. However, the values of ΔG* of poly(vinyl alcohol) in aqueous-butanol were found to be higher than aqueous-methanol, which showed that associations were higher in aqueous-methanol, as compared with aqueous-butanol solutions. The values of entropy change of activation (ΔS*) of viscous flow increased with increase in the concentration of the polymer. The high negative values of entropy change of activation (ΔS*) showed that the solution of the polymer was more ordered in initial state than the activated one.

Keywords: polymer, viscosity, structural analysis, Mark-Houwink equation, thermodynamic parameters, poly(vinyl alcohol)

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Introduction

Poly(vinyl) alcohol is a film-forming and the largest volume synthetic water-soluble resin produced in the world. The resin has wide range of applications in several industries. Viscosity measurement is a suitable tool for a rapid and reliable characterization of the polymer (Rivas et al., 2003; Saeed et al., 2002; Lyoo et al., 2001; Liu et al., 1997; Nakamae et al., 1997; Wang et al., 1997). Solute-solvent and solvent-solvent interactions are the measure of interactions between the solute and solvent, and order and disorder (Johansson et al., 2003; Pekel and Guven, 2002; Shaikh et al., 1998; Ahmed et al., 1990). Literature shows different behaviour of polymer viscosity with respect to concentration and molecular weight. In dilute polymer solutions, changes occur in reduced viscosity with the concentration of the solvent (Lewandowska et al., 2001). Viscosity data as the function of concentration have been extrapolated to infinite dilution by means of the Huggin’s equation (Lewandowska et al., 2001; Ahmed and Ahmed, 1990), which gave the value of intrinsic viscosity [η]:

\[ \eta_p / C = [\eta] + K_H [\eta]^2 C \]  

where:

\( \eta_p \) = specific viscosity

\( \eta_s \) = intrinsic viscosity

\( C \) = concentration

\( K_H \) = Huggin’s constant, showing solute-solvent interactions

Specific viscosity is given by:

\[ \eta_{sp} = \eta_{rel} - 1 \] (dimentionsless)  

where:

\( \eta_{rel} \) = relative viscosity, given by:

\[ \eta_{rel} = \eta / \eta_o \] (dimentionsless)

where:

\( \eta \) and \( \eta_o \) = viscosities of solution and solvent, respectively

The thermodynamic properties show that the intrinsic viscosity [η] and the Huggin’s constant (K_H) are both influenced by changes of solvent power and temperature (Ahmed and Ahmed, 1990). The effect of temperature is expressed by using the following expression:

\[ \eta = A \exp (\Delta E_{\eta}^* / RT) \]  

where:

\( A \) = frequency factor

\( \Delta E_{\eta}^* \) = energy of activation

\( R \) = gas constant

\( T \) = temperature
Studies on the Chemistry Control of Some Selected Drinking and Industrial Waters

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Abstract. Water is abundantly used in heat exchangers and boilers. Water chemistry control is necessary to avoid corrosion and scaling in industrial water and health hazards in drinking water. Water used in different types of boilers has been analysed and its impact on corrosion and scaling has been discussed. Treated and untreated water samples used in heat exchangers have been analysed and their advantages and disadvantages have been discussed. Heavy and toxic metals in water sources from Rawalpindi-Islamabad area, Pakistan, have been analysed and results are reported and discussed. Water samples of primary and secondary systems of nuclear reactors have been analysed and discussed. Deposits and cruds formed in boilers and heat exchangers have been analysed and reported.

Keywords: water chemistry, water quality, industrial water, drinking water, corrosion in boilers, scaling in boilers

Introduction
Water has great influence on all aspects of human life (Ahmed et al., 2000, 1984; Snoeink and Tenkin 1983; Hawkins, 1976). As water is important for human health (Ahmed et al., 2003; ASTM 1981; AWWA, 1971), it is similarly important for industrial applications (AWWA, 1985; Steel and McGhee, 1979). Corrosion alone causes billions of dollars worth of losses to different industries (AWWA, 2001; Butler and Ison, 1979). By maintaining a proper quality control, many billions of dollars can be saved. Corrosion is a complicated process (Kreysa and Eckermann, 1992; Benjamin, 1989) and is different for different types of metals and alloys, thus water quality parameters also vary according to materials and conditions. It is, therefore, important to understand various aspects of corrosion so that proper water quality parameters could be adjusted and maintained. Scaling is the second major problem plaguing the industry (Fair et al., 1966; 1963). A small layer of scales on the boiler and heat exchangers may cause tremendous increase in energy consumption in terms of increased input of oil and gas. Scales formed also cause increase in corrosion. Chemical stabilization of water is necessary to avoid scaling and corrosion problems (Fair et al., 1963). Water quality control to avoid scaling problems is necessary. Fouling and bacterial growth are other problems encountered in the industrial usage of water, but these also lead to scaling and corrosion problems. In the nuclear reactor cooling waters, requirements of water quality control are even more stringent due to the radiation dangers involved (Fangliang, 1994; IAEA, 1993; BNES, 1978).

Different water quality parameters and their effects on corrosion and scaling are discussed in the present study. For this purpose, different water systems and their effects on boilers and heat exchangers were investigated. Quality parameters of the cooling water for nuclear reactors are also discussed. Many types of industrial waters, and corrosion and scale deposits, were analysed and results are reported.

Materials and Methods
Apparatus. The mostly used equipment were pH-meter, potentiograph, titrimeters and 746 VA processor (Metrohm, Switzerland). Other instruments used were polarographic analyzer 174 A with all the relevant electrodes (PAR, USA), conductivity meter (Wescan, USA), flame photometer (Jenway PFP-7, UK), and UV-visible spectrophotometer, ion chromatograph, HPLC and atomic absorption spectrophotometer (Hitachi, Japan). All the glassware used was of Pyrex quality.

Sampling and sample preparation. Water samples were collected in polyethylene or polypropylene bottles. Before the collection of water samples, the bottles were washed with dilute warm nitric acid and rinsed with deionized water. Bottles were again rinsed with the water to be sampled. For the determination of trace metals in water, about 1% HClO4 was added to the bottles before collection of water samples. For the determination of anions, water samples were collected as such and stored at -20 °C and thawed before analysis, or analysis was done immediately after collection.
**Phytochemical Studies on Adhatoda vasica**

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**Abstract.** Reinvestigation of the aerial parts of *Adhatoda vasica* led to the isolation of a new triterpenoid, 3α-hydroxy-oleanane-5-ene (1). The structure of this compound was elucidated and identified by spectral studies.

**Keywords:** triterpene, Acanthaceae, *Adhatoda vasica*, 3α-hydroxy-oleanane-5-ene

---

**Introduction**

*Adhatoda vasica*, one of the two Indian species of the genus *Adhatoda* (Family: Acanthaceae), is well known for its anthelmintic and herbicidal properties (Ikram et al., 1965). Its extracts have been used against various chest ailments, while a number of bioactive constituents have been isolated from this plant (Mehta et al., 1963). A new triterpenoid, 3α-hydroxy-oleanane-5-ene (1) has now been isolated from the aerial parts of this plant, along with a known triterpenoid, taraxerone (2), which are reported here.

**Materials and Methods**

**General experimental procedures.** Optical rotations were measured on JASCO DIP-360. IR spectra were recorded on JASCO 302. UV spectra were recorded on a Hitachi U 3200 spectrophotometer. EIMS, FABMS and HREIMS were recorded on JMS HX 110 with data system DA 5000 and on MAT 112S mass spectrometers. The 1H- and 13C-NMR spectra were recorded on Bruker 400 MHz and 500 NMR spectrometers.

**Plant material.** *Adhatoda vasica* (whole plant; 200 kg) was collected from the suburban areas of Karachi, Pakistan, in December. The plant was identified by Mr. Tahir Ali, Plant Taxonomist, Department of Botany, University of Karachi, Pakistan and a voucher specimen (KUH number 53882) was deposited in the herbarium of the department.

**Extraction and fractionation.** The EtOH extract of the whole plant of *A. vasica* was concentrated to a gum (8 kg). This gum was dissolved in distilled H2O. The aqueous extract was first extracted with pet ether (40-60 °C) and then with CHCl3. The pet ether extract (168.21 g) was loaded on a silica gel column and eluted first with pet ether and then with pet ether-acetone mixtures. Several fractions were obtained. The identical fractions were combined into larger fractions 1-12. Compound 1 was isolated from these fractions.

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**Results and Discussion**

3α-Hydroxy-oleanane-5-ene (1), C30H50O, was obtained as a crystalline solid (m.p. 197-199 °C) by column and preparative thin-layer chromatography of the ethanolic extracts of *A. vasica*. The molecular composition was determined as C30H50O by high-resolution electron-impact mass measurements of the M+ (m/z 426.3861), which indicated six degrees of unsaturation in the molecule. The UV spectrum recorded in methanol showed terminal absorption only, while the infrared spectrum displayed absorptions for OH (3400 cm⁻¹) and C = C (1630 cm⁻¹) groups.

The characteristic fragment ions were found at m/z 166 (fragment a), 260 (fragment b), 148 (fragment c), 205 (fragment d), and 287 (fragment e), indicative of the molecule being a pentacyclic triterpene of the oleanane series. The presence of a double bond in the oleanane series has proved to be readily recognizable by
Synthesis of New 2-Derivatives of 3-(5,6,7,8-Tetrahydronaphthalen-2-yl)Quinoxaline

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(received March 11, 2004; revised February 17, 2005; accepted March 12, 2005)

Abstract. The known compound 3-(5,6,7,8-tetrahydronaphthalen-2-yl)-2-(1H)-quinoxalone was used to synthesize a new series of derivatives. Synthesis of a class of six quinoxaline derivatives, a new series of three hydrazinoquinoxaline-Schiff bases, and a corresponding Mannich base are described. The analytical data on the newly synthesized compounds reported in the paper include their melting points, percent yields, molecular formulae, molecular weights, and percent C, H, N calculated and experimental values. Also given are the IR, 1H NMR, and mass spectral data of these new compounds.

Keywords: tetrahydronaphthalen, quinoxaline, heterocycles, triazines

Introduction
In continuation of our previous work in the drug discovery programme (Ebeid et al., 2004; 1996; 1992; El-Zahar et al., 1994; El-Wassimi et al., 1983; Buu-Hoi et al., 1958), concerning the synthesis of anticipated biologically active 3-(5,6,7,8-tetrahydronaphthalen-2-yl)-heterocycles, such as, triazines (Ebeid et al., 1992; Buu-Hoi et al., 1958), thiazoles and thiazolidinones (Ebeid et al., 2004; 1996; El-Zahar et al., 1994; El-Wassimi et al., 1983), interest was focused to introduce another new series of this class of compounds incorporated into quinoxaline nucleus, which may be useful as key intermediates, using facile methods of preparation, starting with the known compound I, 3-(5,6,7,8-tetrahydronaphthalen-2-yl)-2-(1H)-quinoxalone (Nabih et al., 1984; Metri and Zoorob, 1982). From this compound I, new series of derivatives were synthesized, which included a class of six quinoxaline derivatives II-VII (Fig. 1), a new series of three hydrazinoquinoxaline-Schiff bases VIII-X, and a corresponding Mannich base XI (Fig. 2).

Materials and Methods
All melting points presented in Table 1 are uncorrected values and were taken in open capillaries using the Gallenkamp apparatus. Microanalyses were carried out at the Microanalytical Unit, National Research Centre and the Faculty of Science, Cairo University, Egypt. IR spectra were carried out on FT/IR 300E spectrophotometer Jasco, using KBr discs. 1H NMR spectra were measured in DMSO or CDCl3 using Joel EX-270 NMR spectrometer. Signals were measured with reference to TMS as the internal standard. The mass spectra were recorded on Finnigan SSQ-7000 spectrometer. All reactions were followed up by TLC, using CHCl3/MeOH (9:1, v/v), and/or ethyl acetate/benzene (7:3, v/v) and detected by UV lamp. Analytical data and spectroscopic data of the newly synthesized compounds are respectively presented in Tables 1 and 2. A brief description of the procedure followed for the synthesis of new compounds is given below.

2-Chloro-3-(5,6,7,8-tetrahydronaphthalen-2-yl)quinoxaline; compound II. A mixture of compound I (1.4 g, 0.005 mole) in phosphorous oxychloride (4 ml) was heated in sandbath over the temperature range of 90-130 °C (Buu-Hoi et al., 1958). The solution was cooled by cautiously pouring ice/water and made slightly basic with 30% NaOH solution. If salts separated at this point, these were removed by filtration and the desired compound was extracted with chloroform, concentrated, and the brown residue was separated. The compound II was crystallized from methanol.

2-Hydrazino-3-(5,6,7,8-tetrahydronaphthalen-2-yl)quinoxaline; compound III. To a solution of compound II (1.5 g, 0.005 mole) in phosphorous oxychloride (4 ml) was heated in sandbath over the temperature range of 90-130 °C (Buu-Hoi et al., 1958). The solution was cooled by cautiously pouring ice/water and made slightly basic with 30% NaOH solution. If salts separated at this point, these were removed by filtration and the desired compound was extracted with chloroform, concentrated, and the brown residue was separated. The compound II was crystallized from methanol.

2-Hydrazino-3-(5,6,7,8-tetrahydronaphthalen-2-yl)quinoxaline; compound III. A mixture of compound I (1.4 g, 0.005 mole) in phosphorous oxychloride (4 ml) was heated in sandbath over the temperature range of 90-130 °C (Buu-Hoi et al., 1958). The solution was cooled by cautiously pouring ice/water and made slightly basic with 30% NaOH solution. If salts separated at this point, these were removed by filtration and the desired compound was extracted with chloroform, concentrated, and the brown residue was separated. The compound II was crystallized from methanol.

2-Hydrazino-3-(5,6,7,8-tetrahydronaphthalen-2-yl)quinoxaline; compound III. To a solution of compound II (1.5 g, 0.005 mole) in absolute ethanol, about 5-fold excess of hydrazine hydrate (1.3 g, 0.025 mole) was added. The solution mixture was refluxed for 3 h. Upon cooling, white precipitate was formed which was filtered off and recrystallized from ethanol to give compound III.

3-(5,6,7,8-Tetrahydronaphthalen-2-yl)-2-(3,5-disubstituted pyrazolines and/or pyrazol-1-yl)quinoxalines; compounds IV-VI. To a solution of compound II (0.3 g, 0.001 mole) in 30 ml of absolute ethanol, about 0.001 mole of different β-diketones, namely, ethyl acetoacetate, diethyl malonate and acetyl acetone, respectively, were separately added and refluxed for 3 h. The solvent was evaporated on rotary evaporator and the precipitate formed was recrystallized from acetone/cyclohexane to give the compounds IV-VI, respectively.
Studies on the Chemical Modification of Rice Bran Lipase-1

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Abstract. Rice bran lipase-1 (lip-1) was treated with various groups of specific amino acids modifying reagents. Modification of arginine and histidine residues did not affect the lipolytic activities of the lipases. Acetylation of the lipases with acetic anhydride led to a complete loss of their lipolytic properties. However, citraconylation did not affect the lipolytic properties indicating the involvement of tyrosine residues at or near the active site of lipases. Acetylation of tyrosyl groups with N-acetylimidazole strongly reduced the lipolytic activities of lipases and the loss in activities was restored on deacetylation of tyrosyl groups. Modification of serine residues with diisopropyl fluorophosphate (DFP) inactivated the lipases completely, while the lipolytic activities of the lipases were reduced by about 50% after modification of cysteine residues with 5,5’-dithio-bis-2-nitrobenzoic acid (DTNB). Oxidation of lip-1 by N-bromosuccinimide (NBS) destroyed its activity completely, indicating the involvement of tryptophan residues at the active site. It is suggested from the results presented in this study that tyrosine, tryptophan and serine residues are located at or near the active site of lip-1.

Keywords: Oryza sativa, rice bran lipase-1, amino acids, acetylation, lipase modification

Introduction

Lipases are enzymes that catalyze the hydrolysis of triacylglycerols of animal fats and vegetable oils. These are recognized as being industrially important enzymes (Buhler and Wandrey, 1987; Macrae and Hammond, 1985). These enzymes are able to hydrolyze acylglycerides in aqueous medium and also catalyze the synthesis of esters in organic medium (John and Abraham, 1990). Further, these enzymes, especially those from microorganisms, have received increased attention after they were shown to be active even in nearly anhydrous water immiscible organic solvents (Zaks and Klibanov, 1984).

Chemical modification techniques have been used to study the amino acid residues involved in the active site of the enzyme molecules. Identification of these amino acid residues is a necessary requirement for understanding the lipase structure-function relationship. Many investigators have obtained much information about the catalytic site residues of some hydrolases, such as proteinase (Kaneda and Tominaga, 1975), and carboxypeptidases (Carey and Wells, 1972). Few reports have also been published on the active sites of lipases. With respect to porcine pancreatic lipase alone, it has been confirmed that the enzyme was a serine-histidine enzyme on the basis of the observations of complete inactivation by both paraoxon and photooxidation with methylene blue (De Caro et al., 1981; Maylie et al., 1972). In contrast to the configuration in animal tissues, the active sites of the lipases from higher plants have not yet been studied in detail, except for the observations by Ory et al. (1960) that sulfhydryl group was a part of the active system of castor bean lipases.

Rice bran contains several types of lipases. Basic proteins of these lipases have been purified from rice bran of japonica variety by Aizono et al. (1973) and from indica variety by Sastry and Rao (1971). We have previously reported the purification and characterization of lipase-1 (mol wt 41000) from the rice bran of BR-11 variety of Bangladesh origin (Absar et al., 1999). It is a glycoprotein in nature (carbohydrate 7% and lipid 0.93%), containing high amounts of alanine, lysine, proline, serine, threonine, tryptophan and tyrosine.

The identification of specific amino acid residues within the active sites of lipases is important for understanding the relationship between structure and biological activity. The present investigations were undertaken to examine the active amino groups of lipase-1 (lip-1), after modifications with different group-specific modifying reagents, which are reported here.

Materials and Methods

Rice bran and chemicals used. Rice bran of BR-11 variety was purchased from the local auto-rice mills and the paddy growers authenticated the variety. Lipase-1 (lip-1) from this variety was purified in biologically active form and characterized as reported earlier (Absar et al., 1999). N-acetylimidazole, N-bromosuccinimide (NBS), diethyl pyrocarbonate (DEPC), citraconic anhydride and p-nitrophenylglyoxal were purchased from Fluka Biochemica, Switzerland. Sephadex G-25 was obtained from Pharmacia Fine Chemicals, Upsala, Sweden. Acetic anhydride and hydroxylamine were the products of British Drug House (BDH). All other reagents used, such as iodine, hydrogen peroxide, methylene blue and rose bengal were of analytical grade.
Variations of Heavy Metals in Green Seaweeds from Karachi Coast of Pakistan

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Abstract. The main purpose of this study was to quantify heavy metals (Mg, Fe, Mn, Cu, Ni, Zn, Cr, Pb, Co, Cd) in different species of green seaweeds from the coastal areas of Karachi, Pakistan, to determine the seasonal and annual variability in the concentrations of these metals, and to assess the interrelationships of their concentration in the green seaweeds. Metal concentrations in the green seaweeds showed significant variations. The accumulation of metals by green seaweed was the highest at Buleji coast, while the species of Caulerpa contained the highest concentrations of different metals as compared with other green seaweeds. Interannual variations were also noted in the accumulation of metal concentrations in the seaweeds. The study shows that the seaweeds, although exposed to metal pollutants, were still within the safe limits and can be commercially utilized.

Keywords: heavy metals, green seaweeds, metal pollution, Karachi coast

Introduction

The Karachi coast in Pakistan has a large number of green algal species, many of which occur in great abundance (Qari, 2002; Qari and Qasim, 1988). Algae are the primary producers, which possess a great ability to accumulate heavy metals (Zingde et al., 1976). The metals that enter the marine environment are known to be taken up and accumulated by marine algae and animals (Seeliger and Edwards, 1977; Bradfield et al., 1976; Boyden, 1975; Horne, 1969). Seaweeds selectively adsorb trace elements (Mn, Cd, Co, Cr, Cu, Fe, Ni, Pb, Zn) from the seawater, which are accumulated in their thalli. The accumulated elements vary from species to species. Seaweeds generally contain Mg and Fe in large quantities, up to 15-25% of their dry weight (Qasim, 1980). The inorganic contents appear to be very high when compared with 5-6% in hay and nearly 4% in cereals (Rizvi et al., 2000; Dawes, 1974; Boney, 1969). Basson and Abbass (1992) reported the elemental composition (Mg, Fe, Cd, Cr, Co, Mn, Ni) of four green algae from the Bahrain coastline (Arabian Gulf). The trace metal distribution in green seaweeds of the Indian Ocean has also been well documented by Rao (1992), Agadi et al. (1978), and Zingde et al. (1976). Along the Indian coastline, Parekh et al. (1977) reported the Mg content in green seaweeds at Saurashtra coast, and Rajendran et al. (1993) studied metal concentrations (Mn, Fe, Cu, Zn) in Chaetomorpha antennina and Enteromorpha compressa from Tamil Nadu. Ho (1990) assessed suitability of Ulva lactuca as a bioindicator of trace metals and reported the levels of Mn, Fe, Ni, Cu, Zn, Cd and Pb in Ulva lactuca from the Island of Hong Kong. Ho (1987) reported levels of seven metals in five intertidal green algae, besides other groups, in the Hong Kong waters. Wong et al. (1979) investigated metal contents of the two marine green algae found on the iron ore tailings of Hong Kong Island. Shiber and Washburn (1978) studied Pb in Ulva lactuca from Ras Beirut, Lebanon, and Shiber (1980) also studied the seasonal variation of trace metals (Pb, Cd, Cu, Ni, Fe, Zn, Cr) in Halimeda tuna and Ulva lactuca from Ras Beirut, Lebanon.

The present study was undertaken to gather information to serve as the baseline values of heavy metals in green seaweeds found along the coast of Karachi, Pakistan. The main purpose of this study was to quantify heavy metals (Mg, Fe, Mn, Cu, Ni, Zn, Cr, Pb, Co, Cd) in the green seaweeds present at Buleji, Paradise Point and Nathia Gali of Karachi coast, to determine the seasonal and annual variability in the concentrations of these metals, and to assess the interrelationship of concentrations of heavy metals in the seaweeds at the three different sites along the coast of Karachi.

Materials and Methods

The seaweeds were sampled randomly from the exposed shores of Buleji, Paradise Point, and Nathia Gali at low tide (Fig. 1). A total of forty species of algae were collected from the three locations, Buleji (16), Paradise Point (10), and Nathia Gali (14) over the period of three years (January, 1989 to December, 1991). Buleji is a triangular rocky platform of a wave beaten shore with slightly uneven profile and protruding out
Precision and Accuracy in Elemental Determination in Environmental Samples Using Instrumental Neutron Activation Analysis

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Abstract. Thirty elements were determined in different environmental certified reference materials (CRMs) with high accuracy and precision using instrumental neutron activation analysis (INAA). The relative error of most of the elements was found to be within 10% and the standard deviation was less than 15%. The Z-score, as an analytical performance indicator, was also less than ±2. The accurate determination of various trace and major elements, at extremely low concentrations, usually present in very small amounts of airborne particulate matter on filter media was performed satisfactorily by INAA, which is otherwise regarded as a problem in such determinations. On the other hand, nevertheless, INAA appeared to be an inadequate method for the analysis of Ca because of the low count rate.

Keywords: elemental analysis, environmental elements, precision analysis, environmental contamination, instrumental neutron activation analysis, INAA

Introduction

Trace metals play an important role in biological processes, both as essential components and toxins (Ward et al., 1979). Their determination in environmental samples is, therefore, a subject of considerable interest. An excess or absence of some essential trace elements causes serious problems to the physiology of the body. It is thus very important to check the levels of such trace elements precisely and accurately. Therefore, sensitive analytical methods and equipment are required to measure trace elements, since the quantities of biological samples available for analysis are usually very small. The importance of a sensitive analytical method for trace elements investigations is widely recognized not only for the determination of these elements in biological samples, but also for the important work of evaluation and solution of environmental pollution problems (Chung et al., 2002; Kyotani and Iwatsuki, 2002; Sandroni and Smith, 2002; Marco et al., 1999; Rizzio et al., 1999). Instrumental neutron activation analysis (INAA) is generally recognized as a reference method of choice due to its accuracy and precision. This method has high sensitivity, multielement analysis capability, and nondestructive application. The desirable simple sample treatment, preceding analysis, makes the procedure fast with the added advantage of less reagent consumption and low possibilities of sample contamination.

The objectives of the present work were to check the accuracy and precision of INAA for elemental analysis to determine methodological problems of this analytical technique, if any, and to obtain an insight on its suitability for the analysis of different elements in environmental samples of different origins.

Materials and Methods

Instrumentation and the facilities used. Sample irradiation was carried out at HANARO (24 MW research reactor) in Korea Atomic Energy Research Institute (KAERI). Gamma-ray counting was performed using a high purity Ge-detector of 25% relative efficiency and energy resolution of 1.9 keV at 1332 keV of $^{60}$Co, coupled with 8K-multichannel analyzer (EG&G Ortec, MCB) and a personal computer. GammaVision software was used for the acquisition of gamma-ray spectra and for the evaluation of spectra. Elemental concentration was calculated using Windows PC-code, Labview software, developed at the NAA Laboratory, Korea Atomic Energy Research Institute, with the nuclear data library. For medium and long counting, automatic sample-changer was coupled to the counting system.

Irradiation and gamma-ray counting. Samples were packed in clean polyethylene containers and irradiated using pneumatic transfer system (PTS) with thermal neutrons at the HANARO Research Reactor in Korea Atomic Energy Research Institute. After irradiation, the samples were repacked in preweighed polyethylene vials, the weight was recorded, and gamma-ray was counted. Samples were typically irradiated for 1-3 min for short half-lived nuclides and 1-4 h for medium and long half-lived nuclides.

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Short Communication

Impact of Sugarcane Industry on Environment

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Abstract. The environmental threat posed by the sugarcane industry is reported. Sixteen effluent samples, from four sites, were collected. These samples were analysed for pH, electrical conductivity (EC), total dissolved solids (TDS), Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, PO_4, BOD and COD. The results were compared with the National Environmental Quality Standards (NEQS) recommended for the industrial effluent discharge. These effluent samples were further evaluated for irrigation purposes by the TDS, SAR and RSC values and compared with the recommended irrigation water criteria. Results showed that the effluent samples neither met the standards outlined in the NEQS for pH, EC, BOD and COD, nor were they suitable for irrigation purposes due to the TDS values higher than those recommended for irrigation.

Keywords: sugar mills effluent, effluent quality, aquatic life, irrigation quality, environmental impact

Increased industrialization is a serious cause of water pollution. Industrial effluents contain both the inorganic and organic hazardous materials. The discharge of these effluents on agricultural land, adversely affects the plant and animal life (Nabi and Aslam, 2001; Hamid, 1994). According to a rough estimate, 9,000 million gallons of wastewater is daily discharged into the water bodies by the industries in Pakistan (Saleemi, 1993). The number of sugar mills operating in Pakistan in 1999-2000 was 74 (ASP, 2000). These mills are discharging their effluents into the water bodies without any treatment. These effluents have been reported to have high COD and BOD values, which is harmful to the aquatic life (Bailly, 1997). Presently, the availability of data on the environmental pollution caused by the sugarcane industry is limited (Bailly, 1998). Also, the control being exercised to ward off the hazards caused by the disposal of untreated effluents is extremely lacking (Shah, 1987). The present investigation was carried out to assess whether the sugarcane industry effluents are within the limits of the NEQS in Pakistan (Gazette of Pakistan, 1993), and whether these effluents were suitable for irrigation purpose.

The effluent sampling was done from four sites, 220 ft apart from each other. The sampling was done on a weekly basis for one month, during the peak production period of the sugar industry. The total number of samples collected was 16. The samples were collected in plastic bottles, which were thoroughly rinsed with the effluent to be sampled. These samples were analysed immediately after the sampling for pH, electrical conductivity (EC), total dissolved solids (TDS), Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, PO_4 by following the standard methods (ASTM, 1993). The biochemical oxygen demand (BOD), and the chemical oxygen demand (COD) were determined by the standard methods (AOAC, 1984). The water suitability for irrigation purposes was evaluated in accordance with the methods described by USDA (1954).

Physicochemical characterization of the effluents. The chemical characteristics of the sugar mills wastewaters investigated is given in Table 1. The mean pH values from the four sites were, respectively, 3.79, 4.32, 4.28 and 4.57, which were much below the lower limit of 6-10 of the NEQS in Pakistan. The highly acidic values of the effluents have harmful impact on the microflora and fauna. The low pH is indicative of the presence of acids and the hydrolysis of dissolved salts (Rump and Krist, 1992). Since pH effects the biological and chemical properties of the medium, the determination of the parameter in the wastewaters is, therefore, very significant (Banergi, 1993). The electrical conductivity (EC) values depend on the concentration and degree of dissolution of ions, as well as the temperature and migration velocity of ions in the electrical field. The mean EC values in the investigated effluents ranged between 1278.75 and 2121.25 µs/cm, which are higher than the NEQS of Pakistan (Table 1). The total dissolved solids (TDS) is a measure of the total inorganic and organic substances present in the effluent in the dissolved state. The TDS values of the investigated effluents ranged between 2250 and 3358.75 ppm, which were within the limits of the NEQS.

The Ca concentration ranged between 1247.5 2370.0 ppm, which was higher than 200 ppm suggested by Sharma and Lal (1998). The values of Na, 272.75-364.25 ppm, were also...
Phytochemical Screening and Cytotoxicity of Root Extracts of *Eupatorium odoratum* Against the Shrimp Nauplii of *Artemia salina*

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**Abstract.** Extracts of roots of *Eupatorium odoratum* were fractionated using various organic solvents. The fractions so obtained were petroleum ether extract (F1), solid residue left after ethanol extraction (F2), liquid residue left after ethanol extraction (F3), hexane soluble sub-fraction of F2 (F2-1), dichloromethane-soluble sub-fraction of F2 (F2-2), ethyl acetate-soluble sub-fraction of F2 (F2-3), and 80% aqueous methanol soluble sub-fraction of F2 (F2-4). The root extract fractions were screened for such phytochemicals as sterols, triterpenoids, polyphenols, carbohydrates and reducing sugars, alkaloids, flavonoids, quinones, and tannins. These root extract fractions were further tested for their cytotoxicity in the brine shrimp lethality test. The LC50 values indicated that F1, F2-1 and F2-2 were significantly cytotoxic against the brine shrimp nauplii. The fractions F3, F2-3 and F2-4 showed no cytotoxicity, whereas F2 was mildly cytotoxic in the brine shrimp lethality test.

**Key Words:** *Eupatorium odoratum*, brine shrimp lethality test, phytochemical cytotoxicity, *Artemia salina*, shrimp nauplii

Introduction

*Eupatorium odoratum* is a perennial shrub. In its new habitats it spreads quickly, forms dense thickets and seriously interferes not only with natural vegetation, but also with forestry, pasture and plantation crops. The plant is accordingly known as the forest killer, “banamara”, in the Nepali language. The plant is distributed in the central and eastern regions of Nepal from 400-1500 m altitude (Press et al., 2000). Juice of aerial parts of the plant is used on cuts and wounds to arrest bleeding and promote healing (Taylor et al., 1996). The plant is used as fish poison (Talpatra et al., 1977). It is also used as an ingredient in the preparation of antimalarial mixtures and cough suppressants; chloroform extract of leaves has shown antimicrobial activity (Iwu and Chiori, 1984). Okunji et al. (2000) have reported that the plant was suitable for treating fungal and protozoan diseases. Essential oil of leaves form Ivory Coast showed notable antimicrobial activity against the gram-negative bacteria (*Klebsiella pneumoniae*, *E. coli*, *Pseudomonas aeruginosa*), but no activity was noted towards gram-positive species (Bamba et al., 1993). Ethanol extract of the leaves showed antioxidant activity to protect cultured skin cells (Phan et al., 2001). Triratana et al. (1991) reported that a compound 4,5,6,7-tetramethoxyflavone, isolated from this plant, was found as a blood clotting enhancer factor when studied *in vitro*. Roots of *Eupatorium odoratum* contain the N-oxides of pyrrolizidine alkaloids (Billier et al., 1994). Most plants are toxic to domestic animals and humans (Cheeke, 1989).

Researchers have isolated different classes of compounds from its aerial parts. Some of these are sesquiterpenoids (Chowdhry, 2002; Bedi et al., 2001; Dung et al., 1992), triterpenoids (Ding et al., 2001; Talpatra et al., 1977), pyrrolizidine alkaloids (Billier et al., 1994), flavonoids (Ding et al., 2001; Wollenweber and Roitman 1996; Hai et al., 1995; 1991; Metwally and Ekejiuba, 1981; Barua et al., 1978), fatty acids (Barua et al., 1993), and tannins (Ahmad, 1969).

Very few phytochemical studies have been done on its root portion. The available literature indicates that no previous cytotoxic study has been done on roots of *E. odoratum*. The present study investigated the cytotoxic properties of its root extracts against *Artemia salina* (brine shrimp), along with its phytochemical screening. Brine shrimps have been previously used in bioassay studies for a variety of toxic substances, while this method has been applied to plant extracts in order to facilitate the isolation of biologically active compounds for therapeutics by De Giulio et al. (1992). It has been reported that over 300 novel antitumour and natural pesticidal products were isolated using this bioassay technique for prescreening (McLaughlin et al., 1998).

Materials and Methods

**Plant material.** *E. odoratum* was collected from Tinipipalay, Kabhrepalanchok District, Nepal, in November 2001 and identified by Prof. K.K. Shrestha, a taxonomist in the Central Department of Botany, Tribhuvan University,
Introduction

Phytoalexins, which are induced secondary metabolites, are low molecular weight compounds produced by plant tissues in response to microbial invasion as a defence response, or by treatment of various biotic and abiotic elicitors (Darvill and Albersheim, 1984; Keen, 1975). These compounds prevent the growth of most fungi and some bacteria, but they are also toxic to the producing plant cells (Nicholson and Wood, 2001). The determination of induced secondary metabolites (ISMs) in plant tissues is often taken as a measure of the biochemical responsiveness towards agents eliciting defense mechanisms (Bi and Iqbal, 2000). A simple microtechnique based on UV-visible spectrophotometry is described for the quantification of induced secondary metabolites as a function of time and doses of elicitor preparations.

Materials and Methods

Seaweed collection, extraction and isolation of the high molecular weight crude elicitor “polysaccharides” preparation (HMWCEPs) from algal species have been described in a previous communication (Bi and Iqbal, 1999a).

Elicitor treatment. A general method of elicitor application was employed (Whitehead et al., 1982). 250 g fresh carrots (small size), procured from the local market, were washed with tap water, sterilized with 1% Na-hypochlorite solution, washed extensively with distilled water, and finally rinsed with sterile water. Each carrot was cut into thin slices of equal sizes. About 6-8 pieces were placed in petri-dishes over moist filter paper. In the dose response studies, the carrot samples were treated with 75 µl of 10, 40, 70 and 100 µg glucose eq/ml concentration of HMWCEPs of the three algal seaweeds, *Hypnea musciformis*, *Acanthophora delili* and *Botryocladia leptopoda*. Control samples were prepared by treating the carrot samples with sterile water and by simply wounding the tissues. All the samples were incubated at 25 °C for 24 h in darkness. In another set of experiment, related with time course studies, the treated and control samples were prepared by application of 75 µl test solution of 100 µg concentration. Sterile water, and only wounding, followed by incubation for 6, 12, 24 and 48 h at 25 °C in darkness served as the two controls.

Extraction and estimation of induced secondary metabolites.

After the specified period of incubation, the control and treated samples were dipped in about 50 ml redistilled ethanol (95%) and left overnight for complete extraction. Illumination was avoided, as it may oxidize the components. The extracts were filtered through Whatman filter paper No. 1 and concentrated on a rotary evaporator at 45 °C. The weight of residual carrot slices was taken after drying. Stock solutions were prepared by using extracts equivalent to 1 g dry weight of the treated and control tissues of carrot slices in 2 ml redistilled ethanol. 100 µl
Abstract. The study reports some preliminary observations on the occurrence of *Fusarium* head scab (FHS) disease on wheat under natural conditions. These studies were conducted in nursery trials on the wheat varieties of national and international origin prior to their release for cultivation in Pakistan. During the test trial on 1471 nursery entries, covering varieties of international origin for early and advanced screening, the candidate varieties for national wheat programme, and the commercial varieties, all were noted to show 16% to 59% susceptibility to FHS. These observations have been identified as significant indicators for giving FHS the due status in the national wheat disease programmes, before approving the release of new wheat varieties for farm the field level cultivation.

Keywords: *Triticum aestivum*, Fusarium head scab, national wheat breeding, wheat variety screening.

Bread wheat (*Triticum aestivum* L.) is the staple food and an important cereal crop in Pakistan’s economy. Total acreage of wheat in Pakistan is about 8 million hectares but due to the effects of several factors, the national average yield has remained stagnant at around 2 t/ha during the last decade (ASP, 2003). A number of diseases are responsible for reducing its overall production in the country due to their ability to occur and infect the wheat crop in all growth stages and natural environments. Fifty diseases are reported to occur on wheat in Pakistan, which are considered to be of economic significance (Jiskani, 2001). Some rusts have overshadowed the significant losses caused by other diseases, such as head scab, or *Fusarium* head scab (FHS). The FHS is presently regarded as one of the most important fungal diseases affecting the wheat crop in North America, Europe, China and other parts of the world (Gilbert and Tekauz, 2000; Guo et al., 1999; Miedaner and Schilling, 1997; 1996; Parry et al., 1995). The annual crop losses have been estimated to exceed US $1 billion on account of this disease (Meronuck, 1997; Leu, 1985).

This disease, in Pakistan, has remained an unaddressed and neglected area of cereal pathology. FHS is caused by several species of *Fusarium* (Gilbert and Tekauz, 2000), which occur as soil inhabitants as well as saprophytes on the host crop residues (Wieses, 1987). In addition to causing scab, they also cause seed decay, seedling blight, and crown and root rot of wheat. The FHS disease is unique in its capability to adversely influence all the quantitative and qualitative aspects of the crop (Dowell et al., 1999; Nightingale et al., 1999; Dexter et al., 1997; 1996; McMullen et al., 1997; Gilbert and Tekauz, 1995; Charmley et al., 1994; Bechtel et al., 1985).

Keeping in view the importance of FHS, careful field disease diagnosis and scouting was carried out on early and advanced wheat variety candidates, and the commercial bread wheat material by following the pictorial guide for field identification of wheat diseases and pests (Prescott et al., 1986). These studies were conducted on immature heads of the crop, raised during 2001-2002 at the research farms of Nuclear Institute for Food and Agriculture (NIFA), Peshawar, Pakistan. Intermittent rains and humidity at the field experiment site provided ideal conditions for the build-up of local inoculum and subsequent development of FHS to reach the epidemic level.

Under these natural conditions, preliminary observations on the development of FHS on the varieties cultivated at NIFA were recorded. Varieties under the early trial included three nurseries introduced from CIMMYT/ICARDA, which were International Bread Wheat Screening Nursery (IBWSN), Semi Arid Wheat Screening Nursery (SAWSN), and Wheat Observation Nursery for Drought (WON-D). A total of 859 lines were planted in these three nurseries in strips of adjacent plots. Each entry was planted in two rows of 2.5-m length with 30-cm distance. The advanced trial material comprised of 530 lines planted from National Wheat Disease Screening Nursery (NWDSN) in strips of adjacent plots, and each entry was grown in 1-m row plot at a 30-cm distance. The nursery included advanced lines from the wheat breeding programmes of the country. The candidate material included 40 upcoming future varieties, which were planted in replicated trials where each entry was planted in six rows, 30-cm apart with 5-m row length. The commercial material included the varieties released in the country, and each was planted in two rows of 2.5-m...