INTRODUCTION

About 300 million tonnes of pollutants are being released annually into the atmosphere throughout the world. India alone contributes 10 million tonnes to it in the form of particulates and gaseous pollutants (Ganai et al., 1996). In general, any fuel, which contains sulphur, produces SO₂ on combustion and almost all fuels contain some amount of sulphur, which is considered to be the most important phytotoxic molecule (Legge et al., 1998). SO₂ toxicity to vegetation is well documented and its effects on vegetation have been well reviewed in terms of foliar injury (Malhotra and Khan, 1984; Pavgi et al. 1991; Venkateshwar et al. 1992), physiological and biochemical alterations (Agarwal, 2000 and 2003; Holopainen et al. 1993; Kailunainen et al. 1995) and species specific responses of plants to SO₂ (Jones et al. 1979; Farooq and Beig 1980;). Relations between genetic make up, concentration of the pollutants and prevailing ecological conditions have been studied by various workers like Heek et al. 1965; Ali 1993; Riga et al. 2005. SO₂ has also been seen effecting the metabolism and pigment destruction (Peiser and Yang, 1977; Wang et al, 2005). SO₂ gets well absorbed into the cells affecting various metabolic activities (Pahlich et al. 1972). SO₂ entering the gas phase of a leaf rapidly dissolves in the aqueous phase of cell wall (apoplastic space) and reacts with water to form bisulphite. Aqueous solution of SO₂ contains different species such as H₂SO₃, HSO₃⁻, and SO₃²⁻ and dissolved but unreacted SO₂ (SO₂. H₂O) depending upon the pH of cell (Hocking and Hocking, 1977). The abnormalities caused due to SO₂ include: Membrane damage, plasmolysis, chlorophyll destruction and Genetic material destruction (Seema et al. 1991).

MATERIALS AND METHODS

(i) Preparation of aqueous sulphur dioxide

Aqueous sulphur dioxide of 1000ppm concentration

IMPACT OF AQUEOUS SULPHUR DIOXIDE ON BIOCHEMICAL PARAMETERS OF RUMEX HESTATA

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Key words : SO₂, chlorophyll, Proteins, Sugars, Perrinal herb and Rumex hestata.

ABSTRACT

The impact of aqueous SO₂ on total chlorophyll, phaeophytin, carotenoids, proteins, amino acids, starch, and free sugars of a perennial herb, Rumex hestata was studied for a period of one year. All these, except free sugars, showed a remarkable decrease, attributed to the over all decrease in enzymatic activities, as compared to that under controlled conditions on exposure to sulphur dioxide. The increase in free sugars is attributed to the fact that hydrolytic enzymes get activated on SO₂ treatment and break polysaccharides.
was prepared by dissolving 1.8g of sodium sulphite in 500mL-distilled water. From this solution, the solutions of different concentrations like 250ppm, 500ppm and 750ppm were prepared by appropriate dilutions.

(ii) Treatment of leaf discs with aqueous sulphur dioxide

1g leaf discs of equal dimensions (1 cm dia.) of *Rumex hestata* (locally called as “ABUJ”) were treated with different concentrations (250ppm, 500ppm 750ppm and 1000ppm) of aqueous sulphur dioxide for 4hrs. in glass petri dishes under the light provided by a 100W tungsten electric bulb. According to the recommendations given by Environment Protection Agency (USA) for treating leaf discs with toxicants for primary screening of plants for their sensitivity. Each concentration was compared with the “control” that was run parallel with each sample.

The chlorophyll content was estimated according to the equation given by Strain *et al.* (1971), the phaeophytin according to Vernon (1960) and the carotenoid content was estimated following Duxbury and Yentech (1956). Proteins were estimated according to the standard methodology of Lowry *et al.* 1951 using 100mg% egg albumin as standard. Estimation of amino acids was carried out following the methodology of Lee and Takahashi (1966), that of starch was done according to Montgomery (1982).

**RESULTS AND DISCUSSION**

Table 1 and 2. show the impacts upon chlorophyll, phaeophytin and carotenoid content of *Rumex hestata* on exposure to different concentrations of aqueous SO₂. Total chlorophyll content showed 66.9%, 70.9%, 75.2% and 81.2% decrease at 250 ppm, 500 ppm, 750 ppm and 1000 ppm SO₂ concentrations respectively. Such decrease could be attributed to overall decrease in enzymatic processes. The results are in conformation to the findings of Huang *et al.* (1994 a, b) and Vogelman and Borett (1988).

Similar decreasing trend was depicted by phaeophytin and carotenoids. Total phaeophytin content showed 62.3%, 66.1%, 67.2% and 73.4% decrease at 250 ppm, 500 ppm, 750 ppm and 1000 ppm SO₂ respectively, as compared to that of control. The respective decrease in carotenoids was recorded to

<table>
<thead>
<tr>
<th>Table 1. Impact of different concentrations of aqueous sulphur dioxide on chlorophyll content</th>
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<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>Chlorophyll ‘a’ (μg/mL)</td>
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<td></td>
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<tr>
<td>Chlorophyll ‘b’ (μg/mL)</td>
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<tr>
<td>Total Chlorophyll (μg/mL)</td>
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Data represents the average of three samples analyzed separately ± S.D values in brackets represent %age decrease (-) compared to control.

<table>
<thead>
<tr>
<th>Table 2. Impact of different concentrations of aqueous sulphur dioxide on phaeophytin and carotenoid content</th>
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<tbody>
<tr>
<td>Parameter</td>
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<tr>
<td>Phaeophytin ‘a’ (μg/mL)</td>
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<tr>
<td>Phaeophytin ‘b’ (μg/mL)</td>
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<tr>
<td>Total Phaeophytin (μg/mL)</td>
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<td>Carotenoid (μg/ml)</td>
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</table>

Data represents the average of three samples analyzed separately ± S.D values in brackets represent %age decrease (-) compared to control.
Table 3. Impact of different concentrations of sulphur dioxide on protein and amino acid content

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Concentrations (ppm)</th>
<th>Control</th>
<th>250</th>
<th>500</th>
<th>750</th>
<th>1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (mg/mL)</td>
<td></td>
<td>0.0105 ± 0.108</td>
<td>0.0093 ± 0.108</td>
<td>0.0088 ± 0.05</td>
<td>0.0079 ± 0.105</td>
<td>0.005 ± 0.106</td>
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<tr>
<td></td>
<td></td>
<td>(-11.4)</td>
<td>(-16.1)</td>
<td>(-24.7)</td>
<td>(-52.3)</td>
<td>(-37.6)</td>
</tr>
<tr>
<td>Amino acid (mg/mL)</td>
<td></td>
<td>0.0396 ± 0.014</td>
<td>0.0319 ± 0.010</td>
<td>0.0281 ± 0.010</td>
<td>0.0269 ± 0.006</td>
<td>0.0247 ± 0.004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-19.4)</td>
<td>(-29.0)</td>
<td>(-32.0)</td>
<td>(-37.6)</td>
<td>(-37.6)</td>
</tr>
</tbody>
</table>

Data represents the average of three samples analyzed separately ± S.D. Values in brackets represent %age decrease (-) compared to control.

Table 4. Impact of different concentrations of aqueous sulphur dioxide on Free Sugars and starch content

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Concentrations (ppm)</th>
<th>Control</th>
<th>250</th>
<th>500</th>
<th>750</th>
<th>1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starch (mg/mL)</td>
<td></td>
<td>0.2503 ± 0.04</td>
<td>0.2351 ± 0.04</td>
<td>0.2093 ± 0.02</td>
<td>0.1749 ± 0.01</td>
<td>0.1508 ± 0.03</td>
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<td></td>
<td></td>
<td>(-6.0)</td>
<td>(-16.3)</td>
<td>(-28.4)</td>
<td>(-37.9)</td>
<td>(-37.9)</td>
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<tr>
<td>Free Sugars (mg/mL)</td>
<td></td>
<td>0.129 ± 0.007</td>
<td>0.1494 ± 0.007</td>
<td>0.1778 ± 0.008</td>
<td>0.2286 ± 0.008</td>
<td>0.238 ± 0.008</td>
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<tr>
<td></td>
<td></td>
<td>(+15.8)</td>
<td>(+37.8)</td>
<td>(+77.2)</td>
<td>(+84.4)</td>
<td>(+84.4)</td>
</tr>
</tbody>
</table>

Data represents the average of three samples analyzed separately ± S.D values in brackets represent %age increase (+) or %age decrease (-) compared to control.

be 15.5%, 17.6%, 23.0% and 30.2% at 250 ppm, 500 ppm, 750 ppm and 1000 ppm SO2, comparison to the of control.

Table 3 shows the impact of aqueous SO2 on protein and amino acid content of Rumex hestata. The protein content was observed to decrease by 11.2%, 16.1%, 24.7% and 52.3% at 250 ppm, 500 ppm, 750 ppm, and 1000 ppm SO2 concentrations respectively when compared to control as has also been advocated by Godzik and Linskin (1974), Malhotra and Sarkar (1979), Prasad and Rao (1982) and Yang (1973). Higher concentrations of SO2 possibly break enzymes and protein disulphide bonds into thiosulphonates and thiols this might be the reason for observed decrease in proteins in the present study. With regard to amino acid content of Rumex hestata, again a decrease of 19.4%, 29.6%, 32.0% and 37.6% was observed at 250 ppm, 500 ppm, 750 ppm, and 1000 ppm SO2, respectively. Probable reasons for such a decline in amino acid could be the disturbance in their synthesis, as SO2 affects whole N2- metabolism of plants. Another cause of decline of amino acids might be the loss of ultra structural organization of the cells and destruction of riboromes, as was opined by Godzik and Linsk (1974), Mlodzsionowski and Bailobok (1977), Soikkeli and Tuovinnen (1979) and Yang (1973).

Starch content of Rumex hestata was observed to decrease by 6.0%, 16.3%, 28.4% and 39.7% on exposure to 250 ppm, 500 ppm, 750 ppm, and 1000 ppm SO2 concentrations respectively (Table 4).

As against chlorophyll, carotenoids, phaeophytin, protein, amino acid and starch, Rumex hestata showed a general increase in its free sugar content. An increase of 15.8%, 37.8%, 77.2% and 84.4% was observed in free sugars content of Rumex hestata at 250 ppm, 500 ppm, 750 ppm and 1000 ppm SO2 respectively (Table 4). This increase could be attributed to the breakdown of polysaccharides by the action of hydrolytic enzymes that get activated on SO2 treatment (Farooq and Beg, 1982).

REFERENCES

Duxbury, A.C. and Yentech, C.S. 1956. Plankton pigment


