Phytoremediation of Phenanthrene from soil by Sorghum

Extended Abstract

Contaminated lands around oil fields, especially soils contaminated by Polyaromatic hydrocarbons (PAHs) are the common problem in these areas. PAHs such as Phenanthrene, Naphthalene, Benzo-a-pyrene are the major pollutant in the fields around petroleum refineries and arise largely as a result of coal and oil burning and other refineries activities. This causes an actual or potential threat to the environment and human, so removing them from polluted soil and water is necessary. In this regard, biological methods including "phytoremediation", as a new approach, are effective and economical. The aim of Phytoremediation in contaminated lands is using the ability of plants to uptake, accumulate, degrade and removing toxic substances. This is a promising technology for the clean-up of petroleum contaminated soils, especially in the tropical area where climatic conditions favor plant growth and microbial activity and therefore the financial resources can be limited. Grass species are excellent candidates for Phytoremediation due to their extensive fibrous root system, which allow for more interaction between the rhizosphere microbial community and the contaminant. The present study was conducted to investigate the role of a warm season grass type, Sorghum vulgare Pers. Sudananse, in Phenanthrene, a major pollutant in soils around oil and gas fields, removal. The experiment was done in a greenhouse scale with climatic conditions similar to mentioned region, in 16 weeks growth period.

Physicochemical parameters of agricultural soil were determined by standard methods as follows:

- pH and EC determination in saturated extract of soil
- Micro and macro element determination
- Organic carbon content
- Soil texture by soil particle size determination
- Field capacity

98% Phenanthrene from Aldrich chemical company was used as contamination source. Studies showed that contaminant limits in the region is in the range of 13-17 mg/kg, so three concentrations of Phenanthrene, 10-15-20 mg/kg, was added to soil. Spiked soil was placed in 30 kg capacity blocks with 110×46 cm dimensions and then Sorghum seeds were planted in 4-5 cm of surface. Treatments were as follows:

- Control : (Planted samples in non polluted soils)
- Unpl: Unplanted contaminated soil(10-15-20 mg/kg respectively)
- P1,2,3: Planted contaminated soil(10-15-20 mg/kg respectively)

Phenanthrene content in soil and plant tissues was extracted to determine pollutant concentration in different times. The fate and presence of PAHs in plant root and rhizosphere may be predicted from their $K_{ow}$ or octanol-water partition coefficient which is characteristic for each organic compound and indicates their water solubility. Partitioning of compounds to the root surface from the soil solution is directly proportional to know values and inversely proportional to solubility.
Compounds with $\log K_{ow} > 3$ will strongly absorb by roots, so it seems that Phenanthrene with $\log K_{ow} > 4.46$ will store in root and cannot translocate toward upper parts of plants. The concentration of Phenanthrene in soil and plant tissue was measured by HPLC. Chlorophyll content was measured by a chlorophyll meter in 7, 9, 10 and 12th weeks. Produced biomass was determined at 12 and 16th week. Statistical analysis, T-Test and Tukey test, was done by SPSS program. Results showed that in 4 weeks after planting there was no appreciable difference between treatments, while in 5th week a considerable reduction in Phenanthrene concentration in planted soil compared with unplanted soil was occurred (Figure 1). Figure (2) shows the Phenanthrene accumulation in plant root.

Table (1) shows the reduction of pollutant in soil after 16 weeks.

<table>
<thead>
<tr>
<th>Conc. (ppm)</th>
<th>Removal in Unplanted Treatments (mg.plot$^{-1}$)</th>
<th>Removal in planted Treatments (mg.plot$^{-1}$)</th>
<th>Removal in Unplanted Treatments (%)</th>
<th>Removal in planted Treatments (%)</th>
<th>Removal ratio (planted/unplanted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>195.5</td>
<td>252.3</td>
<td>76.8</td>
<td>99.86</td>
<td>1.29</td>
</tr>
<tr>
<td>15</td>
<td>328.2</td>
<td>389.0</td>
<td>81.0</td>
<td>99.89</td>
<td>1.20</td>
</tr>
<tr>
<td>20</td>
<td>413.4</td>
<td>513.2</td>
<td>80.1</td>
<td>99.86</td>
<td>1.24</td>
</tr>
</tbody>
</table>

Table (2) shows the accumulation and biological degradation effect in the process. Figures (3) and (4) show the chlorophyll and biomass content in planted treatment compared with control.
Relatively constant amounts of chlorophyll and biomass indicates plant's resistance and positive response to overcome the toxicity of Phenanthrene and also the lack of translocation of pollutant in plant's upper parts, which has a great effect in food chain and heath. On the other hand, the accumulation in root and contaminant removal trend shows that this plant is able to reduce soil contamination by increasing biological degradation.

Considering obtained results it could be find that in planted treatments there was a 20% increase in pollutant removal comparing to the unplanted treatments. Furthermore, it was shown that the most of the Phenanthrene was degraded in the rhizosphere region and it didn't migrate toward upper parts of the plant. Also, it was shown that Phenanthrene didn't affect plants physiological activities. All results was verified statistically in 95% significance level (P<0.05).

**Key words**
PAHs, Phytoremediation, Adsorption and absorption, Accumulation, Phenanthrene, Contaminated soil