SUNFLOWER (*HELIANTHUS ANNUUS* L.) - A POTENTIAL CROP FOR ENVIRONMENTAL INDUSTRY

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Abstract

Sunflower applications in phytotechnologies for the clean-up of inorganic and organic contaminants and pollutants are reviewed in this compilation. There have been several apprehensions on the application of phytoremediation technology. High bioproductivity and biomass yield are must for the success of this strategy. The phytoextraction coefficient of sunflowers is higher compared to many other species. Sunflower is a proven laboratory and field example for the emerging environmental industry. It is the most promising terrestrial candidate for metal and radionuclide removal in water. Rhizofiltration of U from the water using sunflower plants was demonstrated in pilot-scale experiments. Sunflower accumulates Cs and Sr, with Cs remaining in the roots and Sr moving into the shoots. Published research reports have indicated that sunflower, accelerated the mineralization of 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T) in an abandoned pasture, forest land and a floodplain. Chelator assisted metal accumulation; mycorrhizal fungi enhanced toxic trace elements accumulation and tolerance of the plants are increasingly considered for the remediation mine spoils.

Introduction

There has been a general feeling among scientists that phytoremoval of environmental contaminants and pollutants is a temporary solution. However, the large body of scientific information that is available as on today erased this disbelief and new areas are emerging in the field of phytotechnologies (McCutcheon and Schnoor 2003). Sunflower (*Helianthus annuus* L.) is of the most promising environmental crops that is being used in a diverse situations for environmental celan-up.

Sunflower in early days is a popular ornamental. However, in recent years its importance as environmental crop is being increasingly recognized. Dehulled seeds are used in oultry feed (Table 1). Agronomic experiments conducted on farm research site in India using recycles organic manure from integrated farming system (cows, goats, poultry etc…) have substantially increased the growth and yield (data not shown). Agronomic trials in

typical mediterranean climate where winter precipitations average about 500 mm, brackish water irrigated sunflower crops performance and productivity are satisfactory contributing to sustainable agriculture and also find alternative solution to drought.

Table 1: Sunflower seed oil constituents and composition

Whole seed		Fatty cid content in oil	
Constituent	Composition	FA	Range (%)
Hull	21-27	Myristic	5-7
Oil	48-53	Palmitic	3-5
Protein	14-19	Stearic	0.3-0.8
Soluble sugars	7-9	Arachidic	0.6-0.8
Fibre	16-27	Oleic	22-50
Ash	2-3	Linoleic	40-70

At a contaminated wastewater site in Ashtabula, Ohio, 4-week-old sunflowers were able to remove more than 95% of uranium in 24 h (Dushenkov et al. 1997a,b, 1995). Except for sunflower (*Helianthus annuus*) and tobacco (*Nicotiana tabacum*), other non-Brassica plants had phytoextraction coefficients less than one. Rhizofiltration has been employed using sunflower at a U.S. Department of Energy (DOE) pilot project with uranium wastes at Ashtabula, Ohio, and on waterfrom a pond near the Chernobyl nuclear plant in the Ukraine. Sunflowers accumulated Cs and Sr, with Cs remaining in the roots and Sr moving into the shoots (Dushenkov and Kapulnik 2002) (Figure 1). Soils from an abandoned pasture, a forest, and a floodplain near Cincinnati, OH, were cleaned using an association of plants comprising sunflower, timothy grass and red clover and accelerated the mineralization of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) (Figure 1).

Uranium (U) contamination of ground water poses a serious environmental problem in uranium mining areas and in the vicinity of nuclear processing facilities. Preliminary laboratory experiments and treatability studies indicate that the roots of terrestrial plants can be efficiently used to remove U from aqueous streams (rhizofiltration). Almost all of the U removed from the water in the laboratory using sunflower plants was concentrated in the roots. Rhizofiltration technology has been tested in the field with U-contaminated water at concentrations of 21—874 µg/L at a former U processing facility in Ashtabula, OH. The pilot-scale rhizofiltration system provided final treatment to the site source water and reduced U concentration to <20 µg/L before discharge to the environment. System performance was subsequently evaluated under different flow rates permitting the development of effectiveness estimates for the approach (Dushenkov et al. 1997a,b)

Terrestrial plants are thought to be more suitable for rhizofiltration because they produce longer, more substantial, often fibrous root systems with large surface areas for metal sorption. Sunflower (*Helianthus annuus* L.) removed Pb and U (Dushenkov et al., 1997a), ^{137} Cs, and ^{90} Sr (Dushenkov et al., 1997b) from hydroponic solutions. Rhizofiltartion was found to be appropriate for the cleanup of Sr from surface water using hydroponic and field experiments. A pond near the Chernobyl nuclear reactor was phytoremediated with sunflowers and their roots accumulated large quantities of radionuclides with bioaccumulation coefficient greater than 600 for both shoots and roots (Negri and Hinchman 2000). The role of synthetic chelates and Mycorrhizal fungi phytoremoval of contaminats has been evaluated in a number of investigations (Tabl2).

Table 2: Application of sunflower in phytotechnologies for clean up of heavy metals, radionuclides and organic contaminants and pollutants (in reverse chronology)*

Lab or field study	Reference
Soil-to-plant transfer factors of natural uranium and radium	Rodriguez et al 2006
Comparative effect of Al, Se, and Mo toxicity on NO_3- assimilation	Ruiz et al 2006
Phytoextraction of excess soil phosphorus	Sharma et al 2006
Trace metal accumulation, movement, and remediation in soils receiving animal manure	Sistani et al 2006
Accumulation of radioiodine from hydroponic system	Soudek et al 2006a
^{137}Cs and ^{90}Sr uptake	Soudek et al 2006b
The influence of EDDS on the uptake of heavy metals in hydroponic system	Tandy et al 2006
Removal of polycyclic aromatic (PAH) hydrocarbons from contaminated soils	Gong et al 2005a and 2006
Dissolution and removal of PAHs	Gong et al 2005b
Leaching and uptake of heavy metals in EDTA-assisted phytoextraction process	Chen et al 2004
Response of antioxidants grown on different amendments of tannery sludge: metal ccumulation potential	Singh et al 2004
^{137}Cs uptake	Soudek et al 2004
EDTA and citric acid role on phytoremediation of Cd, Cr, and N	Turgut et al 2004
Accumulation of copper	Lin 2003
EDTA-assisted heavy-metal uptake in a association with poplar at a long-term sewage-sludge farm	Liphadzi et al 2003
Trace element and nutrient accumulation two years after the Aznalcollar mine spill, Spain	Madejon et al 2003
Uptake and translocation of plutonium in hydroponics	Lee et al 2002a
Uptake of plutonium from soils - a comparative study with *Brassica juncea*	Lee et al 2002b
Mycorrhizal fungi enhanced accumulation and tolerance of chromium	Davie et al 2001
Accumulation of heavy metals in a association with Sorghum as affected by the Guadiamar spill.	Murillo et al 1999
Removal of Cd^{2+}, Cr^{6+}, Cu^{2+}, Mn^{2+}, Ni^{2+} and Pb^{2+} in miniature rhizofiltration batch experiments	Dushenkov et al 1997a
Rhizofiltration of U, Sr and Cs using 4 week-old plants	Dushenkov et al 1997b

* = the list may not be exhaustive

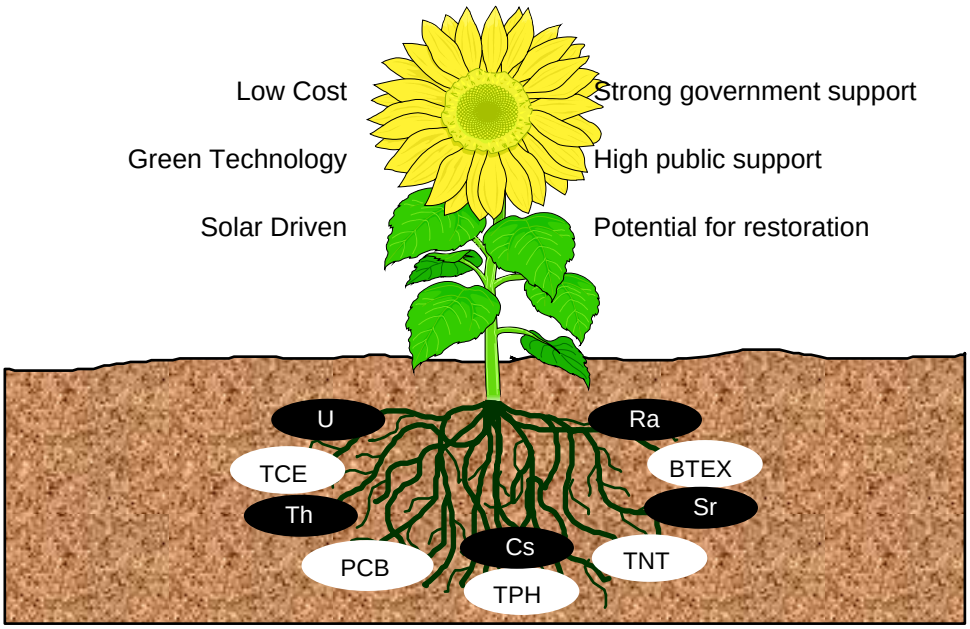

Figure 1: Sunflower as a potential environmental crops for phytotechnologies to clean-up inorganic and organic contaminants and pollutants

***Helianthus annus* L.**

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Abundant biomass
Trace element accumulation including radionuclides

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Soil amendment with chelators viz., HEDTA (hydroethylenediaminetriacetic acid), NTA (nitrilotriacetic acid) and FYM (farm yard manure) enhanced metal uptake in pot and field experiments

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Harvesting

Crop rotation with other environmental crop e.g. *Brassica juncea*

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Biodiesel and industrial feed stock

Figure 2: Sunflower as an environmental crops for production of biodiesel through cultivation on metal contaminated soils

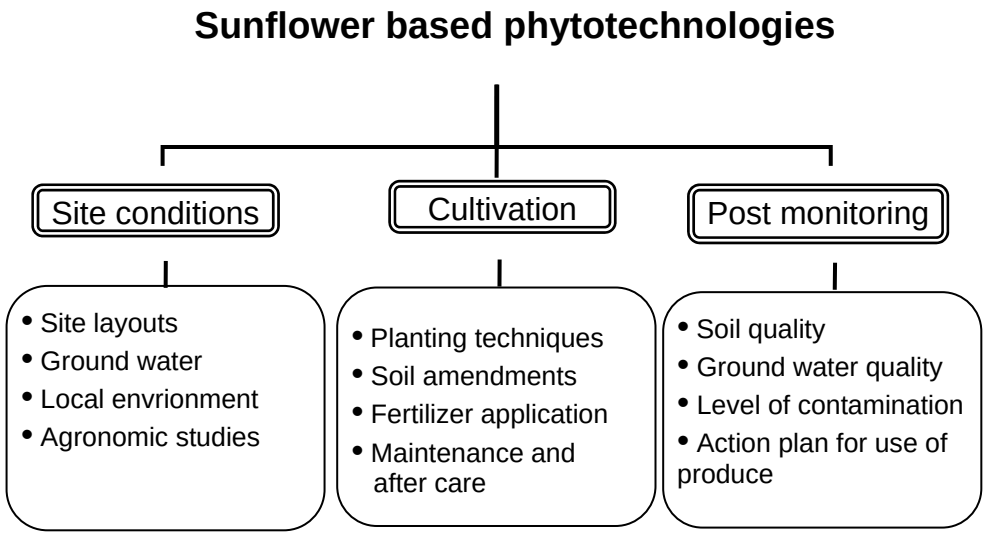

Figure 3: Assessment and applicability of sunflower as an environmental crops for phytotechnologies

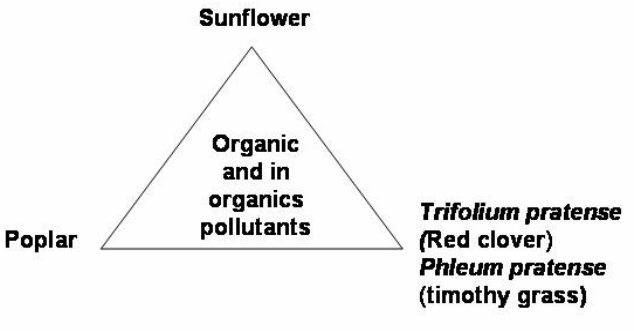

Figure 4: Long-term phytotechnological applications of sunflower in association with tree crops, legumes and grasses for the clean up of sewage sludge, heavy metals, radionuclides and organic contaminants and pollutants

Conclusions

The frequently asked questions (mechanisms, diversity, efficacy and safety related)

- How does phytoremediation works ?
- Disagreement or disbelief among scientists about environmental clean-up?
- Often, some say it is only temporary solution?

- How are plants selected ?
- How to dispose of the plants contaminated in the process of phytoremediation ?
- Will phytoremediation work on every contaminated/ polluted site ?
- How do we know that pytoremediaiton is really working ?
- Is the biomass produced from the exercise of phytoremediation usable ?

All these questions have satisfacoty answers and Phytotechnologies today have reached the site from lab-pilot scale and field trials (Figures 2-4)

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