

SUMMARY AND CONCLUSIONS

OBELIKAN.COM

6. Summary

Heavy metals pollution represents an important environmental problem. The sorption by algae has emerged as a cheaper and an efficient alternative for the removal of heavy metals from low strength wastewaters.

So, in this investigation we studied the bioremediation of low quality water by algae, and the change that might take place in germination, growth and some related physiological activities of wheat and faba bean after being subjected to low quality water (drainage water and synthetic solution) and algal treated water.

Therefore, part of this work conducted in laboratory and the other part as pots experiments:

Laboratory experiments:

A- Four marine algal species i.e. *Ulva lactuca* (green), *Pterocladia capillacea*, *Jania rubens* and *Corallina mediterranea* (red) were collected and prepared to determine the optimum conditions for biosorption.

The obtained results could be summarized as follows:

- 1- Little biosorption of heavy metals occurred under highly acidic and alkaline conditions. The highest removal percentage of heavy metals by almost algal biomass was occurred at pH 5-7.
- 2- The percent of heavy metals removal increased with rise in contact time up to 60 min and after that there was no

considerable change in adsorption percentage with further increase in contact time.

- 3- The maximum biosorption efficiency of the metal ions was attained at about biomass dosage 40 g/L.

B-According to the preliminary experiments, three species (*U. lactuca.*, *P. capillacea* and *J. rubens*) were selected for treatment of low quality water to study its effect on seed germination and the seedling enzymes activity of wheat and faba bean.

- 1- The final percentage germination of wheat grains and faba bean seeds decreased gradually with increasing heavy metals concentration in low quality water. While, the percentage improved and increased with algal treatment.
- 2- The enzyme activities of growing seedlings concerning to peroxidase and catalase were found to be variable among the two plant species with respect to heavy metals concentration in both algal treated and non- treated water

Green house pot experiments.

- 1- Considerable decrease in the growth criteria in the two test plant organs (shoot, root, leaf) at two different stages of growth induced by heavy metals stress compare to control. However, algal treatment enhanced the different growth parameters when compared with non-algal treated water.
- 2- The biosynthesis of the photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) was markedly decreased with increasing heavy metals concentration. But algal treatment induced a considerable increase in the

- various pigment content in both tested plants when compared with those of non-algal treated water
- 3- Increasing heavy metals concentration in low quality water caused an inhibitory effect on the accumulation of estimated metabolites (carbohydrates and protein) in the two test plant seeds. On the other hand, algal treatment caused a stimulatory effect on the above mentioned parameters when compared with those of non- algal treated water
 - 4- An increase of heavy metals content in poor quality water induced an increase in the accumulation of heavy metals in wheat grains and faba bean seeds. But algal treated water induced decrease in heavy metals concentration compared with those of non-algal treated water.

Marine algal species *U. Lactuca*, *J. Rubens* and *P. capillacea* are good and efficient biosorbents for heavy metals from waste and low quality water, and reduce the effect of heavy metals stress on plant growth. Thus they may constitute a cheap and a renewable natural source of biosorbent that can be used in water treatment technology applications.

OBELIKAN.COM

REFERENCES

O
B
E
I
K
A
N
.
C
O
M

References

- Abantika, M.; Raikamal, P.; suparna, P. and Rita, K. (2008):** Effect of lead toxicity on wheat plant. *Indian Agriculturist*, **52** (3/4): 179– 184.
- Abd El-Hady, E. A. (2002):** Safety of wheat grains irrigated by treated sewage effluent water for human consumption. *Ann. Agric. Sci., Moshtohor*, **40** (4): 217- 2192.
- Abd El- Kader, N. I. K. and Mahmoud, E. (2007):** Feasibility re-use of treated drainage polluted water on faba bean (*Vicia Faba*) yield and its content of heavy metals African Crop Science Conference Proceedings Vol. 8. pp., 1527- 1530.
- Abdel-latif, A. (2008):** Cadmium induced changes in pigment content, ion uptake, proline content and phosphoenolpyruvate carboxylase activity in *Triticum aestivum* seedling. *Australian J., Basic and Appl. Sci.*, **2** (1): 57– 62.
- Abdel-shafy, H. I. and Aly, R. O. (2002):** Water issue in Egypt: Resources, pollution and Protection. *Endeavors, An Rev., Article of CEJOEM*. **18** (1): 3- 21.
- Abu Al- Rub, F. A. M.; El- Nass, H.; Benyahia, F. and Ashour, L. (2004):** Biosorption of nickel on blank alginate beads, free and immobilized algal cell, *Process Biochem.*, **39**: 1767- 1773.

References

- Agrawal, S. B. and Mishra, S. (2007):** Effects of supplemental ultraviolet-B and cadmium on growth, antioxidants and yield of *Pisum sativum* L. *Ecotoxicology and Envi. Safety*.
- Ahaly, N.; Kanamacdi, R. D. and Ramachandra, T. V. (2005):** Biosorption of chromium by(VI) from aqueous solution by the husk of Bengal gram (*Cicer arietinum*), *Eur. J. Biotechnol.* 8: 258- 264.
- Ahluwalia, S. S. and Goyal, D. (2007):** Microbial and plant derived biomass for removal of heavy metals from wastewater. *Bioresource Tech.*, 98: 2243– 2257.
- Ahmed, A. M.; Heikel, M.M. and Shaddad, M. A. (1977):** Photosynthesis of some economic plants as affected by salinization treatments. II –safflower and maize. *Egypt. J. Bot.* 20: 17- 27.
- Ahmed, A. M.; Heikel, M. M. and Saddad, M. A. (1979):** Growth, photosynthesis and fat content of some oil producing plants as influence by some salinization treatments. *Phyton (Aust.)* 19: 259- 267.
- Ahmed, A. M. Heikel, M.M. and Shaddad, M.A. (1980):** Changes in growth, Photosynthesis and fat content of some oil producing plant over arange of salinity stresses. *Acta Agronomica*, 32: 370- 375.

- Ahsan, N.; Lee, D. G.; Lee, S. H.; Kang, K. Y.; Lee, J. J.; Kim, P. J.; Yoon, H. S; Kim, J. S. and Lee, B. H. (2007): Excess copper induced physiological and proteomic changes in germinating rice seeds. *Chemosphere*, **67**: 1182-1193.
- Aksu, Z.; Kutsal, T.;Gün, S.; Haciosmanoğlu, N. and Gholaminejad, M. (1991): Investigation of biosorption of Cu(II), Ni(II) and Cr(VI) ions to activated sludge bacteria. *Environ. Technol.*, **12**, 915-92.
- Aksu, Z.; Sağ, Y. and Kutsal, T. (1990): A comparative study of the adsorption of chromium(VI) ions to *C. Vulgaris* and *Z. Ramigera*, *Environ. Technol.*, **II**, 33- 40.
- Aldesuquy, H. S.; Haroun, S. A.: Abo-Hamed, S. A. and Al-saied, A. A. (2011): Physiological studies of some polyamines on wheat plants irrigated with wastewater: 1. Osmolytes in relation to osmotic adjustment and grain yield. *Phyton (Horn)*, **50** (2): 263- 286.
- Ali, R. M. (2000): Role of putrescine in salt tolerance of *Atropa belladonna* Plant. *Plant sci.*, **152**: 173- 179.
- Amany El- Sikaily; El Nemr, A.; Azza khaled, Ola Abdelwehab (2007): Removal of toxic chromium from wastewater using green alga *Ulva lactuca* and its activated carbon, *J. Hazardous Materials*, **148**: 216- 228.

References

- An Younjoo. (2004):** Soil ecotoxicity assessment using cadmium sensitive plants. *Envi. Pollu.*, **127** (1): 21– 26.
- An, Y. J.; Kim, Y. M.; Kwon, T. I. and Jeong S.W. (2004):** Combined effect of copper, cadmium, and lead upon *Cucumis sativus* growth and bioaccumulation. *Sci. Total. Environ.*, **326**: 85– 93.
- A.O.A.C. (1965):** Association of Official Analytical Chemists. Washington DC, U.S.A.
- A.O.A.C. (1990):** Association of Official Analytical Chemists. Washington DC, U.S.A.
- Apiratikul, R. and Pavasant, P. (2006):** Sorption isotherm model for binary component sorption of copper, cadmium and lead ions using dried green macroalga, *Caulerpa lentillifera*. *Chem. Eng. J.*, **119**: 135– 145.
- Apiratikul, R. and Pavasant, P. (2008):** Batch and column studies of biosorption of heavy metals by *caulepra lentillifera*. *Bioresource Technol.*, **99**: 2766– 2777.
- Arun, K. S.; Cervantes, C.; Loza-Tavera, H. and Avudainayagam, S. (2005):** Chromium toxicity in plants. *Environ. Int.*, **31**: 739- 753.
- Asgharipour, M. R.; Khatamipour, M. and Razavi-omrani, M. (2011):** Phytotoxicity of cadmium on seed germination,

early growth, proline and carbohydrate content in two wheat varieties. *Adv. in Envir. Bio.*, **5** (4): 559- 569.

Atici, O.; Agar, G. and Battal, P. (2005): Changes in phytohormone contents in chickpea seeds germinating under lead or zinc stress. *Biol. Plant*, **49**: 215- 222.

Baranowska-Mor, E. A. (2003): Roślinne mechanizmy tolerancji działanie metali ciężkich. *Kosmos*, **52**: 283.

Barcelo, J.; Cabot, C. and Poschenrieder, C. (1986): Cadmium induced decrease of water stress resistance in bush bean plants (*Phaseolus vulgaris* L.). II. Effects of Cd on endogenous abscisic acid levels. *Plant Physiol.*, **125**: 27- 34.

Bergmeyer, H. U. (1974): Methods of Enzymatic Analysis 1. Second ed. Academic Press, New York.

Bertran, M. and Poirier, I. (2005): Photosynthetic organisms and excess of metals. *Photosynthetica*, **43** (3): 345- 353.

Bhardwaj, P.; Chaturvedi, A. K. and Prasad, P. (2009): Effect of Enhanced Lead and Cadmium in soil on Physiological and Biochemical attributes of *Phaseolus vulgaris* L: Nature and Science., **7**(8): 63- 75. (ISSN: 1545- 0740).

Billet, J. E.; Koeppe, D. E. and Miller, R. J. (1974): Sorption of heavy metals cations by corn mitochondria and the effects on electron and energy transfer reaction. *Physiology*, **30**: 226- 230.

References

- Bonnet, M.; Camares, O. and Veisseire, P. (2000):** Effects of zinc and influence of *Acremonium lolii* on growth parameters, chlorophyll fluorescence and antioxidant enzyme activities of ryegrass (*Lolium perenne* L. cv Apollo). *J. Exp. Bot.*, **51**: 945– 953.
- Brinza, L.; Dring, M.J. and Gavrilesco, M. (2005):** Ability of different algal species to take up heavy metals from waste water: a review. *The phycologist*, **68**: 30– 31.
- Brinza, L.; Nygard, C. A.; Dring, M. J.; Gavrilesco, M. and Benning, L. G. (2009):** Cadmium tolerance and adsorption by the marine brown algal *Fucus vesiculosus* from the Irish sea and Bothnian sea. *Biores. Techn.*; **100**: 1727– 1733.
- Bruzynski, M. (1987):** The uptake and transpiration of water and the accumulation of lead by plants growing on lead chloride solutions. *Acta Soc. Bot. Poloniae*, **56**: 271- 280.
- Bunluesin, S.; Kruatrachue, M.; Pokethitiyook, P. Upatham. S. and Lanza, G. R. (2007).** Batch and continuous packed column studies of cadmium biosorption *Hydrilla verticillata*. *J. Bioscience and Bioengineering*. **103** (6): 509- 513.
- Burhan, N. S. Shaukat, S. and Tahira, A. (2001):** Effect of zinc and cobalt on germination and seedling growth of *Pennisetum americanum* (L.) Schumann and *Parkinsonia aculeata* L. *Pakistan Journal of Bio. Sci.*, **4** (5):575-580.

- Bybordi, A. and Tabatabaei, J. (2009):** Effect of Salinity Stress on Germination and Seedling Properties in Canola Cultivars (*Brassica napus L.*), *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, **37**(2): 71 – 76.
- Cakmak, I. (2000):** Possible role of zinc in protecting plant cells from damage by reactive oxygen species. *New Phytol.*, **116**: 185-205.
- Castillo, F. J.; Miller, P. R. & Greppin, H. (1987):** Extra cellular biochemical markers of photochemical oxidant air pollution damage to Norway Spruce. *Experientia*, **43**: 111-115.
- Cavusoglu, K.; Yalcin, E. and Ergene, A. (2009):** The cytotoxic effects of zinc and cadmium metal ions on root tip cells of *Phaseolus vulgaris L.* (Fabaceae). *SDU J. Sci. (E- J.)*, **4**(1):1-11.
- Chaffei, C.; Pageau, K.; Suzuki, A.; Gouia, H.; Ghorbel, M. H.; Masclaux-Daubress, C. (2004):** Cadmium toxicity induced changes in nitrogen management in *Lycopersicon esculentum* leading to a metabolic safeguard through an amino acid storage strategy. *Plant and Cell Physiology*, **45**(11):1681-1693.
- Chandra, R.; Bharagava, R. N.; Yadav, S. and Mohan, D. (2009):** Accumulation and distribution of toxic metals in wheat (*Triticum aestivum L.*) and Indian mustard (*Brassica*

campestris L.) irrigated with distillery and tannery effluents
J. Haz. Materials, **162** (2/3) 1514 – 1521.

Chen, W. and Mulchand, A. (2005): Environmental
Biotechnology: challenges and opportunities for chemical
engineers. American Instit., Chemic. Engin., **51**: 690– 695.

Chen Y.; Cao, X.; Lu, Y. and Wang X. R. (2000): Effect of rare
earth metal ions and their EDTA complexes on antioxidant
enzymes of fish liver. Bull. Environ. Contm. Toxicol. **65**:
357- 365.

Chong, K. H. and Volesky, B. (1996): Metal biosorption
equilibrium in a ternary system. Biotechnol. Bioeng., **49**:
629- 638.

**Choudhary, S. P.; Bhardwaj, R.; Gupta, B. D.; Gupta, P. R. K.,
Kanwar, M. and Pitamber Dutt, P. (2010):** Changes
induced by Cu^{2+} and Cr^{6+} metal stress in polyamines, auxins,
abscisic acid titers and antioxidative enzymes activities of
radish seedlings. brazilian society of plant physiology.

**Christian Taty-costodes, V.; Fauduet, H.; porte, C. and
Delacroix, A. (2003):** Removal of cd (II) and Pb (II) ions,
from equeous solutions by adsorption onto sawdust of Pinus
sylvestries. J. Haz.Materials, B **105**: 121– 142.

**Ci Dun, W.; Jian, D. ; Wollenweber, B.; Dai TingBo; Jing Qi;
Cao, W. (2010):** Cadmium stress in wheat seedlings:

References

growth, cadmium accumulation and photosynthesis. *Acta physiologiae Plantarum*, **32** (2): 365- 373.

Clijsters, H. and Van Assche, F. (1985): Inhibition of photosynthesis by heavy metals. *Photosynthesis Research*, **7**: 31-40.

Costa, G. and Spitz, E. (1997): Influence of cadmium on soluble carbohydrates, free amino acids, protein content of *in vitro* cultured *Lupinus albus*. *Plant Sci.*, **128**: 131- 140.

Da Costa A. C. A.; Tavares; A. P. M. and De France F. P. (2001): The release of light metals from a brown seaweed (*Sargassum sp.*) during zinc biosorption in a continuous system. *Electronic journal of Biotechnology*, **4**: 42- 53.

Davis, A.; Volesky, B. and Mucci, A. (2003, a): A review of the biochemistry of heavy metals biosorption by brown algae. *Water Res.*, **37** (18): 4311 - 4330.

Davis, T. A.; Llanes, F.; volesky, B and Mucci, A. (2003,b): Metal selectivity of *sorgassum sp.* and their alginates in relation to their a- l- guluronic acid content and conformation. *Environ. Sci., Tech.*, **37** (2): 261– 267.

Davis, T. A.; Volesky, B. and Vieira, R. H. S. F. (2000): *Sargassum sp.* seaweed as biosorbent for heavy metals. *Wat. Res.*, **34** (17): 4270 – 4278.

References

- Dharam, S.; Kamlesh, N. and Sharma, Y.K. (2006):** Toxicological impact of copper sulphate on wheat germination and certain biochemical parameters. *J. Appl. Biosci.*, **32** (2): 154– 159.
- Dharam, S.; Kamlesh, N. and Sharma, Y. K. (2007):** Response of wheat seed germination and seedling growth under copper stress. *J. Environ. Biol.*, **28**: 409- 414.
- Dietz, K. J.; Baier, M. and Kramer, U. (1999):** Impact of heavy metals on photosynthesis. In heavy metal stress in plants: From Molecules to Ecosystems, eds. M. N. V. Prasad and J. Hagemeyer, 73- 97.
- Draobzkiewicz, M.; Skórzyńska-Polit, E. and Krupa, Z. (2004):** Copper- induced oxidative stress and antioxidant defence in *Arabidopsis thaliana*. *Bio Metals*, **17**: 379– 387.
- Drazkiewicz, A. (1994):** Chlorophyllase: Occurrence, functions, mechanism of action, effects of external and internal factors. *Photosynthetica*, **30**: 321- 331.
- Duan, Y. Ping.; Yuan, S.; Tu Shihua; Feng, WQ.; Xu Fie; Zhang, Z. W.; Chen, Y. Er.; Wang, X.; Shang, J. and Lin, H. H. (2010):** Effects of cadmium stress on alternative oxidase and photosystem II in three wheat cultivars. *Zeitschrift Fur Naturforschung. Section C., Biosci.*, **65** (1/2): 87– 94.

- Eid, M. A. and shereif, M. M. (1996):** Effect of wastewater irrigation on growth and mineral contents of certain crops (green house conditions). Egypt. J. Soil. Sci, **36** (1/4): 109–118.
- Eleiwa, M. M. E. (2004):** Response of lupin and wheat to soil contamination with heavy metals. Egypt. J. Soil, Sci., **44**(1):1–17.
- El-Gamal, Sabah M. and Salwa A. R. H. (2003):** Counteracting the deleterious effects of lead and cadmium on tomato plants by using yeast, garlic and eucalyptus extracts. Minufiya J. Agric. Res., **28**(3): 737-755
- Engelman, R. and Le-Roy, P. (1993):** Sustaining water, population and the future of renewable water supplies. Population Action International, population and Envir., Program, Washington, D.C, PP: 302– 318.
- Faheed, F. A. (2005):** Effect of lead stress on growth and metabolism of *Eruca sativa* . Seedling. Acta Agron. Hung., **53**: 319- 327.
- Faizan, S.; Kausar, S. and Perveen, R. (2011):** Varietal differences for cadmium-induced seedling mortality, foliar toxicity symptoms, plant growth, proline and nitrate reductase activity in chickpea (*Cicer arietinum* L) *Research Article Biology and Medicine, Vol 3 (2) Special Issue*: 196-206.

References

- Fales, F.W. (1951):** The assimilation and degradation of carbohydrates by yeast cells. *J. Bio. Chem.* **193**: 113-124.
- Fargasova, A. (1994).** Effect of Pb, Cd, Hg, As and Cr on germination and root growth of *Sinapsis alba* seeds. *Bull. Environ. Contam. Toxicol.*, **52**: 452- 456.
- Farrag, R. M. F. (2003):** Land degradation as affected by irrigation water quality in El-Fayoum Governorate. Ph.D. Thesis, Fac. Agric., El-Fayoum branch, Cairo Univ.
- Fatma A. Abdo, Dalia M. A. Nassar, Elham F. Gomaa and Rania M. A. Nassar (2012):** Minimizing the Harmful Effects of Cadmium on Vegetative Growth, Leaf Anatomy, Yield and Physiological Characteristics of Soybean Plant [*Glycine max* (L.) Merrill] by Foliar Spray with Active Yeast Extract or with Garlic Cloves Extract: Research J. Agriculture and Biological Sciences, **8**(1): 24- 35, ISSN 1816-1561
- Fecht-Christoffers, M. M.; Maier, P. and Horst, W. J. (2003):** Apoplastic peroxidase and ascorbate are involved in manganese toxicity and tolerance of *Vigna unguiculata*. *Physiol. Plant.*, **117**: 237- 244.
- Feizi, M. (2001):** Effect of treated wastewater on accumulation of heavy metals in plants and soil. 52nd IEC Meeting of the International Commission on irrigation and Drainage.

References

International workshop on Wastewater reuse Management, Seoul, Korea, 19- 20 sept.,: 137– 146.

Figueira, M. M.; Volesky, B.; Ciminelli, V. S. T. and Roddick, F. A.(2000): Biosorption of metals in brown seaweed biomass. *Water Research*. 34: 196- 204.

Fouda, R. A. and Arafa, A. A.(2002): Alleviation of cadmium toxicity on soybean, *Glycine max* (L.) Merr. By inoculation with *Bradyrhizobium* and vesicular-arbuscular mycorrhizae or kinetin. *J. Agric. Sci. Mansoura Univ.*, 27(11): 7385-7403.

Freeman J. L.; Persans M. W.; Nieman K.; Albrecht C.; Peer W.; Pickering I. J. and Salt D. E. (2004) :Increased glutathione biosynthesis plays a role in nickel tolerance in *Thlaspi* nickel hyperaccumulators. *Plant Cell*, 16: 2176-2191.

Gallego, S. M.; Benavídes, M. P. and Tomaro, M. L.(1999): Effect of cadmium ions on antioxidant defense system in sunflower cotyledons. *Biol.Plantarum*, 42: 49- 55.

Gajewska, E. and Sklodowska, M. (2008): Differential biochemical responses of wheat shoots and roots to nickel stress: antioxidative reactions and proline accumulation. *Plant Growth Regulation*, 54 (2): 179– 188.

References

- Gajewska, E. and Sklodowska, M. (2010):** Differential effect of equal copper, cadmium and nickel concentration of biochemical reactions in wheat seedlings. *Ecotoxicology and Envir., Safety*, **73** (5): 996– 1003.
- Gajewska, E.; Sklodowska, M.; slaba, M. and Mazur, J. (2006):** Effect of nickel on antioxidative enzyme activites, proline and chlorophyll contents in wheat shoots. *Biologia Plantaram*, **50** (4): 653– 659.
- Gao, S.; Yan, R.; Cao, M.; Yang, W.; Wang, S. and Chen, F. (2008):** Effects of copper on growth, antioxidant enzymes and phenylalanine ammonia-lyase activities in *Jatropha curcas* L. seedling plant soil environ., **54** (3): 117– 122.
- Gavrilescu, M. (2004):** Removal of heavy metals from environment by biosorption. *Engin. In life Sci.*, **3**: 219– 232.
- Ge Cailin; Ding, Y.; Wang, Z. ; Wan, DZ. ; Wang Yu.; Shang Qi; and Luo, S. (2009):** Response of wheat seedlings to cadmium, mercury and trichlorobenzene stresses. *J. Envir. Sci.*, **21** (6): 806– 813.
- Geuns, J. M. C.; Cuypers, A. J. F.; Michiels, T.; Colpaert, J.V.; Laere, A.V.; Broeck, K. A. and AVandecasteele, C.H. (1997):** Mung bean seedlings as bioindicatorsfor soil and water contamination by cadmium. *The Sci. of the total Envi.*, **203**: 183- 197.

- Ghanbari, A.; Koupai, J. A. and semiromi, J. T. (2007):** Effect of municipal wastewater irrigation on yield and quality of wheat and some soil properties in Sistan Zone. J. Sci. and Tech., Agric. and Natural Resources, **10** (4A): 59– 75.
- Ghani, A. and Wahid, A. (2007):** Varietal differences for cadmium-induced seedling mortality and foliar toxicity symptoms in mung bean (*Vigna radiata*). International Journal of Agriculture and Biology, **9**(4): 555- 558.
- Godzik, B. (1993):** Heavy metals content in plants from zinc dumps and reference area. Pol. Bot. Stud., **5**: 113-132.
- Grifferty, A. and Barrington, S. (2000):** Zinc uptake by young wheat plants under two transpiration regimes, J. Environ. Qual., **29**, 443- 446.
- Gupta, R.; Ahuja, P.; Khan, S. Saxena, R. K. and Mohapatra, H. (2000):** Microbial biosorbents: meeting challeng, of heavy metal pollution in aqueous solutions. Current Sci., **78**: 967– 973.
- Gupta, S.; Satpati, S.; Nayek, S. and Garai, D. (2009):** Effect of wastewater irrigation on vegetables in relation to bioaccumulation of heavy metals and biochemical changes. Environ. Monit. Assess. doi 10.1007/s10661-009-0936-3.

References

- Gupta, V. K.; Rastogi, A.; Saini, V. K. and Jain, N. (2006):** Biosorption of copper (II) from aqueous solutions by *Spirogyra* species. *J. Colloid and Interface Sci.*, **296**: 59– 63.
- Halliwell, B. and Gutteridge, J. M. C. (1993):** Free radicals in Biology and Medicine. Clarendon, Oxford.
- Hamid, N.; Bukhari, N. and Faiza, Jawaid (2010):** Physiological responses of *Phaseolus vulgaris* to different lead concentrations. *Pak. J. Bot.*, **42**(1): 239- 246.
- Hanif, M. A.; Nadeem, R.; Bhatti, H. N.; Ahmed, N. R. and Ansari, T. M. (2007):** Ni(II) biosorption by *Cassia fistula* (golden shower) biomass, *J. Hazard. Mater.*, **139**: 345- 355.
- Hegedüs, A.; Eedei, S. and Horváth, G. (2001):** Comparative studies of H₂O₂ detoxifying enzymes in green and greening barley seedlings under cadmium stress. *Plant Science*, **160**:1085- 1093.
- Herrero, R.; Cordero, B.; Iodeiro, P.; Rey-Castro, C. and Vicente, S. M. E. (2006):** Interactions of cadmium (II) and protons with dead biomass of marine algae *Fucus sp.* *Marine Chem.*, **99**: 106– 116.
- Horsfall, M. and Spiff, A. I. (2005):** Effect of metal ion concentration on the biosorption of Pb²⁺ and Cd²⁺ by *Caladium bicolor* (wild cocoyam). *Afric. J. Biotech*, **4**: 191 – 196.

References

- Hsu, F. H. and Chou, C. H. (1992):** Inhibitory effects of heavy metals on seed germination and seedling growth of *Miscanthus* species., Bot. Bull. Sin., 33: 335- 342.
- Ianelli, M. A.; Pietrini, F.; Fiore, L.; Petrilli, L. and Massacci, A. (2002):** Antioxidant response to cadmium in *Phragmites australis* plants. Plant Physiol. Biochem., 40: 977- 982.
- Ibrahim, W. M.; Azab, Y. A. and Kenawy, I. (2005):** Applied phycological studies with special reference to bioremoval of toxic heavy metals and treatment of industrial wastewaters using algal biofilters. Ph.D., Mansoura University, Egypt.
- Ibrahim, W. M.; Ismail, A. M. and Azab, Y. A. (2011):** Bioremoval of toxic heavy metals from industrial effluents by fixed –bed columns of brown algae. Egypt. J. Exp. Biol. (Bot.), 7(2): 203 – 209.
- Iftikhar, A.; Bhatti, H. N.; Hanif, M. A. and Nadeem, R. (2009):** Kinetic and thermodynamic aspects of Cu (II) and Cr (II) removal from aqueous solutions using rose waste biomass. J. Haz. Materials, 161: 941– 947.
- Irigoyen, J. J.; Emerich, D.W. and Diaz, S. (1992):** Water stress induced changes in concentrations of proline and total soluble sugars in nodulated alfalfa (*Medicago sativa*) plants. Physiol. Plants. 84: 55-60.

References

- Jalali, R.; Ghafourian, H.; Asef, Y.; Davarpanah, S. J. and sepehr, S. (2002):** Removal and recovery of lead using nonliving biomass of marine algae. *J. Haz. Materials*, B 92: 253 – 262.
- Jamal, S. N.; Iqbal, M. Z. and Athar, M. (2006):** Phytotoxic effect of aluminum and chromium on the germination and early growth of wheat (*Triticum aestivum*) varieties Anmol and Kiran. *International J. Envir. Sci., and Tech.*, 3 (4): 411–416.
- Jeliazkova, A. E. and Craker, L. E. (2002):** Seedgermination of some medicinal and aromatic plants in a heavy metal environment. *J. Herbs, Species and Medicinal PlanTS*, 10 (2).
- John, P.; Ahmad, P.; Gadgil, K. and Sharma, S. (2009):** Heavy metal toxicity: Effect on plant growth, biochemical parameters and metal accumulation by *Brassica juncea* L. *Int J. Plant Prod*, 3: 65- 76.
- Jones J. B. J. (1989):** Soil Testing and plant Analysis. Laboratory Manual Benton Laboratory Inc. Athens Georgia U. S. A.
- Jouzdan, O.; Fares, F. and Abedalgawad, G. (2007):** The effect of using urban treated and untreated effluents on soil and agricultural crops pollution in Syria (Damascus - Ghouta). *Amer – Eurasian, J. Agric and Envir. Sci.*, 2 (1): 51– 61.

- Jyoti, M.; Vivek, P. and Nandita, S. (1994):** Effects of some heavy metals on root growth of germinating seeds of *Vicia faba*. J. Envir., Sci. and Health. Part A, Envir. Sci., and Eng., 29 (10): 2229– 2234.
- Kaewsarn, P. (2002):** Biosorption of copper (II) from aqueous solutions by pre-treated biomass of marine algae *Padina sp.* Chemosphere, 74: 1081– 1085.
- Kaewsarn, P. and Qiming Yu. (2001):** Cadmium (II) removal from aqueous solutions by pro-treated biomass of marine alga *Padina sp.* Envir. Pollu., 112: 209– 213.
- Kamel, H. A. (2008):** Lead accumulation and its effect on photosynthesis and free amino acids in *Vicia faba* grown hydroponically. Australian J. Basic and Appl. Sci., 2 (3): 438– 446.
- Kar, M. and Mishra (1976):** Catalase, peroxidase and polyphenol oxidase Activities during rice leaf senescence. Plant physiol. 57: 315.
- Karthikeyan, S.; Balasubramanian, R. and Iyer, C. S. P. (2007):** Evaluation of the marine algae *Ulva fasciata* and *Sargassum sp.* For the biosorption of Cu(II) from aqueous solutions, Bioresour. Technol., 98: 452- 455.

References

- Kasim, W. A. (2005):** The correlation between physiological and structural alterations induced by copper and cadmium stress in broad beans (*Vicia faba* L.). Egypt. J. Biol., 7: 20– 32.
- Kastori, R.; Plesnicar, M.; Sakac, D.; Pankovic, D. and Arsenihjevic Maksimovic, I. (1998):** Effect of excess lead on sunflower growth and photosynthesis. J. Plant Nutrition, 21 (1): 75: 85.
- Kaur, G.; Singh, P. S.; Batish, D. R. and Kohli, R. K. (2012):** Growth, photosynthetic activity and oxidative stress in wheat(*Triticum aestivum*) after exposure of lead to soil J. Environ. Biol.
- Khudsar, T.; Iqbal, M. M. and Sairam, R. K. (2004):** Zinc induced changes in morpho-physiological and biochemical parameters in *Artemisia annua*. Biol. Plant., 48: 255– 260.
- Kilic, M.; Yazici, H. and Solak, M. (2009):** comprehensive study on removal and recovery of copper(II) from aqueous solution by NaOH- pretreated *Marrubium globosum* ssp. *globosum* leaves power: Potential for utilizing the copper(II) condensed desorption solutions in agricultural applications. Bioresource Technology, 100: 2130- 2137.
- Klimmek, S.; stan, H. J.; wilke, A.; Bunke, G. and Buchholz, R. (2001):** Comparative analysis of biosorption of cadmium, lead, nickel and zinc by algae. Environ. Sci. Technol., 35: 4283– 4288.

References

- Knörzer, O. C.; Durner, J., Böger, P. (1996):** Alterations in the antioxidative system of suspension-cultures soybean cells (*Glycine max*) induced by oxidative stress. *Physiol. Plant*, **97**, 388.
- Kong, F. X.; Hu W.; Chao S. Y.; Sang W. L. and Wang, L. S.;**(1999): hysiological responses of oxidative stress of SO₂. *Environ and Exp. Bot.* **42**: 201- 209.
- Kopyra, M. and Gwozdz, E. A. (2003):** Nitric oxide stimulates seed germination and counteracts the inhibitory effect of heavy metals and salinity on root growth of *Lupinnu luteus*. *Plant Physiol. Biochem.*, **41**, 1011-1017.
- Krupa, Z.; Baranowska, M. and Orzol, D. (1996):** Can anthocyanine be considered as heavy metal indicator in higher plants? *Acta Physiologica Plant*, **18** (2): 147- 151.
- Kumar, R.; Mehrotra, N. K.; Nautiyal, B. D.; Kumar, P. and Singh, P. K. (2009):** Effect of copper on growth, yield and concentration of Fe, Mn, Zn and Cu in wheat plants (*Triticum aestivum* L.) *J. Environmental Biology*, **30**(4) 485- 488.
- Kumar, V.; Yadav, D.V. and Yadav, D. S. (1990):** Effect of nitrogen sources and copper levels on yield, nitrogen and copper contents of wheat. *Plant Soil*, **126**: 79- 83.

References

- Kumar, Y. P.; King, P. and Prasad, V. S. R. K. (2006, a):** Removal of copper from aqueous solution using *Ulva fasciata* sp. A marine green algae. J. Haz. Mat., B, 137: 367– 373.
- Kumar, Y. P.; King, P. and Prasad, V. S. R. K. (2006, b):** Comparison for adsorption modeling of copper and zinc from aqueous solution by *Ulva fasciata* sp. J. Haz. Materials, 137: 1246- 1251.
- Latif, H. H. (2010):** The influence of nickel sulphate on some physiological aspects of two cultivars of *Raphanus sativus* L. Arch. Biol. Sci., Belgrade, 62 (3): 683- 691.
- Lepp, N. W. (1981):** Effect of heavy metals pollution on plants. 2.
- Li Feili ; Ni Lijia ; Yuan Jin and Sheng, G. D. (2010):** Cultivation practices affect heavy metal migration between soil and *Vicia faba* (broad bean). Chemosphere, 80 (11): 1393– 1398.
- Lin, C. C. and Kao, C. H. (2000):** Effect of NaCl stress on H₂O₂ metabolism in rice leaves, Plant Growth Regul., 30: 151- 155.
- Linger, P.; Ostwald, A. and Haensler, J. (2005):** *Cannabis sativa* L. growing on heavy metal contaminated soil: growth, cadmium uptake and photosynthesis. Biologia Plant., 49 (4): 567- 576.

References

- Liu, D.; Wang, X.; Chen, Z.; Xu, H. and Want, Y. (2010):** Influence of mercury on chlorophyll content in winter wheat and mercury bioaccumulation. *Plant, Soil and Envir.*, **56** (3): 139– 143.
- Liu, Xi. and zhang, Sh. Z. (2007):** Intraspecific differences in effects of co-contamination of cadmium and arsenate on early seedling growth and metal uptake by wheat. *J. Envir. Sci.*, **19** (10): 1221– 1227.
- Liu, Xi.; Zhang, Sh. Z.; Shan, Xia. Q. and Christie, P. (2007):** Combined toxicity of cadmium and arsenate to wheat seedlings and plant uptake and antioxidative enzyme responses to cadmium and arsenate co-contamination. *Ecotoxicology and Envir., safety*, **68** (2): 305– 313.
- Louteseti, S.; Danielidis, D. B.; Economou- Amilli, A.; Katsaros, Ch.; Santa, R. and Santas, Ph. (2009):** The application of micro-algal/ bacterial biofilter for the detoxification of copper and cadmium metal wastes. *Biores. Techn.*, **100**: 2099– 2105.
- Luksiene, B. and Racaite, M. (2008):** Accumulation of heavy metals in spring wheat (*Triticum aestivum* L.). overground and underground parts. *Envir. Res., Engi. And Manage.*, **4**: 36– 41.
- Macfarlane, G. R. Burchett, M. D. (2001):** Photosynthetic pigments and peroxidase activity as indicators of heavy

References

metal stress in grey mangrove, *Avicennia marina* (forsk.)-
vierh. Marine Pollution Bulletin, **42** (3):233- 240.

Madhulika Gupta (2011): Effect of zinc on seed germination and seedling growth of *vicia faba*, Cv. T-44. Bionotes, **12** (4): 133– 134.

Mahmood, T.; Islam, K. R. and Muhammad, S. (2007): Toxic effects of heavy metals on early growth and tolerance of cereal crops. Pakistan J. of Botany, **39** (2): 451– 462.

Maksymiec, W.; W'ojcik, M. and Krupa, Z. (2007): Variation in oxidative stress and photochemical activity in *Arabidopsis thaliana* leaves subjected to cadmium and excess copper in the presence or absence of jasmonate and ascorbate. *Chemosphere*, **3**(6): 421– 427.

Malkoç, E. and Nuhoglu, Y. (2003): The removal of chromium(VI) from synthetic wastewater by *Ulothrix zonata* . Fresenius Environmental Bulletin.

Mamata, M.; Sahu, R. K.; Sahu, S. K. and Padhy, R. N. (2009): Growth, yield and elements content of wheat (*Triticum aestivum*) grown in composted municipal solid wastes amended soil. Envir., Devolp. and Sustainability, **11** (1): 115– 126.

Mane, A. V.; Sankpal, R. R.; Mane, L. A. and Ambawade, M. S. (2010): Cadmium chloride induced alteration in growth

References

and cadmium accumulation in *Triticum aestivum* L., var. MP Lok 1. J. of chemical and pharmaceutical Res. ; 2 (5): 205–215.

Mansour, M. M and Kamel, E. A. R. (2005): Interactive effect of heavy metals and gibberellic acid on mitotic activity and some metabolic changes of *Vicia faba* L. Plants. Cytologia, 70 (3): 275–282.

Martins, B. L.; Cruz, C. C. V.; Luna, A. S. and Henriques, C. A. (2006): Sorption and desorption of Pb^{2+} ions by dead *sargassum* sp. biomass Bioch. Eng. J., 27: 310–314.

Mazen, A. M. A. (1995): assessment of heavy metal accumulation and performance of some physiological parameters in *Zea mays* and *Vicia faba* L grown on soil amended by sewage sludge resulting from sewage water treatment in the State of Qatar. Qatar Univ. Sci. J., 15(2), 353- 359.

Mazen, A.; Faheed, F.A. and Ahmed, A.F. (2010): Study of potential impacts of using sewage sludge in the amendment of desert reclaimed soil on wheat and jews mallow plants. Barzilian Archives of Biol. and Tech., 53 (4): 917–930.

McGeer, J. C.; Szebedinszky, C.; McDonald, D. G. and Wood, C. M. (2000): Effects of chronic sub lethal exposure to waterborne Cu, Cd or Zn in rainbow trout. 1: Lono-regulatory disturbance and metabolic costs. *Aqua. Toxicol.*, 50: 231–243.

References

- McKay, G.; Ho YS, Ng JCY. (1999) :** Biosorption of copper from wastewater: a review. *Sep Purif methods*, **28**: 87- 125.
- Mckersie, B. D. (1996):** Oxidative Stress, University of Guelph.
- Mehta, S. K. and Gaur, J. P. (2001):** Characterization and optimization of Ni and Cu sorption from aqueous solution by *Chlorella Vulgaris*. *Ecol. Eng.*, **18**: 1– 13.
- Metzner, H.; Rau, H. and Senger, H. (1965):** Untersuchungen Zur Synchronisierbarkeit einzelner-pigment. Mangel Mutanten Von *Chlorella*. *Planta.*, **65**: 186- 194
- Miller, P. R.; Parmeter, J. R.; Flick, B. H. and Martinez, C. W. (1969):** Ozone dosage response of ponderosa pine seedlings. *J. Air Pollut. Control Assoc.*, **19**: 435- 438
- Miller, G.; Shulaev, V. and Mitter, R. (2008):** Reactive oxygen signaling and abiotic stress. *Physiologia Plantarum*, **133**: 481– 489.
- Mishra, SN; Singh, DB. (2000):** Accumulation of lead and cadmium in upper parts of mustard (*Brassica juncea*) seedlings in response to putrescine. *Indian J. Expt. Biol.*, **38**: 814- 818.
- Mithöfer, A.; Schulz, E.B. and Bolan, D.W. (2004):** Biotic and heavy metal stress response in plants: evidence for common signals. *FEBS Lett.*, **566**: 1.

- Mittler, R. (2002):** Oxidative stress, antioxidants and stress tolerance. *Trends Plant Sci.*, 7:405– 410.
- Mittler, R.; Vanderauwera, S.; Gollery, M. and Van Breusegem, F. (2004):** Reactive oxygen gene network of plants. *Trends Plant Sci.*, 9: 490-498.
- Mocquot, B.; Vangronsveld, J.; Clijstres, H. and Mench, M. (1996):** Copper toxicity in young maize (*Zea may* L.) plants: effect on growth, mineral and chlorophyll contents, and enzyme activities. *Plant and Soil*, 182: 287- 300.
- Mohan, B. S. and Hosetti, B. B. (1997):** Potential phytotoxicity of lead and cadmium to *Lemna minor* L. growth in sewage stabilization ponds. *Environ. Pollut.*, 98: 233- 236.
- Monteiro, MS.; Santos, C.; Soares, A. and Mann, R. M. (2009):** Assessment of biomarkers of cadmium stress in lettuce. *Ecotoxicol Environ Saf.*, 72: 811–818.
- Munzuroglu, O. and H. Geckil, H. (2002):** Effects of metals on seed germination, root elongation, and coleoptile and hypocotyl growth in *Triticum aestivum* and *Cucumis sativus*. *Environ. Contam. Toxicol.*, 43: 203– 213.
- Naddafi, K.; Nabizadeh, R.; saeedi, R.; Mahvi, A. H.; Vaezi, F.; Yaghmaeian, K.; Ghasri, A. and Nazmara, S. (2007):** Biosorption of lead (II) and cadmium (II) by protonated

References

sargassum glaucescens biomass in a continuous packed bed column. J. Haza. Mate., **147**: 785– 791.

Narwal, R. P. and Singh, M. (1993): Effect of cadmium and zinc application on quality of maize. *Indian J. Plant Physiol.*, **34**: 170- 173.

Nitika; Sinhal, V. K.; Gupta, S. K. and Dashrath singh. (2007): Effects of mercury and its antagonistic effect with magnesium and sucrose on growth and NR activity in *Triticum aestivum* L. *Envir. And Ecol.*, **25** (3): 509– 514.

Odjegba, V. J and Fasidi, I. O. (2006): Effect of heavy metals on some proximate composition of *Echhornia crassipes*. *Journal of Applied Sciences & Environmental Management*, **10**(1): 83- 87.

Odjegba; V. J. and Fasidi; I. O. (2007): Changes in antioxidant enzyme activities in *Eichhornia crassii* (Pontederiaceae) and *Pistia stratiotes* (Araceae) under heavy metal stress *Rev. Biol. Trop.* **55** (3- 4): 815- 823.

Oncel, I.; Keles, Y. and Ustun, A.S. (2000): Interactive effects of temperature and heavy metal stress on the growth and some biochemical compounds in wheat seedlings. *Envir. Pollution*, **107**: 315– 320.

Ozer, A.; Gurbuz, G.; Calimli, A. and Korbahti, B. (2009): Biosorption of copper (II) ions on *Enteromorpha prolifera*:

References

Application of response surface methodology (RSM).
Chem.. Eng. J., **146**: 377– 387.

Pál, M.; Horváth, E.; Janda, T.; Páldi, E. and Szalai, G. (2006):
Physiological changes and defense mechanisms induced by
cadmium stress in maize. Plant Nutr Soil Sci., **169**: 239–
246.

**Palma, JM; Sandalio, LM; Corpas, FJ; Romero-Puertas, MC;
McCarthy, I. and del Rio, LA. (2002):** Plant proteases,
protein degradation and oxidative stress: role of
peroxisomes. Plant Physiol Biochem., **40**: 521– 530.

Panda, S. K. ; Chaudhury, I. and Khan, M. H. (2003): Heavy
metals induce lipid peroxidation and effect antioxidants in
wheat leaves. Biological Plantarum, **46** (2): 289– 294.

Pandey, S. N. (2006): Accumulation of heavy metal (Cd, Cr, Cu,
Ni and Zn) in *Raphanus sativus L.* and *Spinacia oleracea*
L. plants irrigated with industrial effluent. J. Environ. Biol.,
27: 381- 384.

Passardi, F.; Cosio, C.; Penel, C. and Dunand, C. (2005):
Peroxidases have more functions than a Swiss army knife.
Plant Cell Rep., **24**: 255- 265.

**Patra, M.; Bhowmik, N.; Bandopadhyay, B. and Sharma, A.
(2004):** Comparison of mercury, lead and arsenic with
respect to genotoxic effects on plant systems and the

References

development of genetic tolerance Environ. Exp. Bot., **52**: 199- 223.

Pavasant, P.; Apiratikul, R.; sungkhum, V.; Suthiparinyanant, P.; Wattanachira, S. and Marhaba, T. F. (2006): Biosorption of Cu^{+2} , Cd^{+2} , Pb^{+2} and Zn^{+2} using dried marine green macroalga *Caulepra lentillifera*. Biores. Techn, **97**: 2321– 2329.

Pence, NS; Larsen, PB; Ebbs, SD; Letham, DL; Lasat, MM; Garvin, DF; Eide, D. and Kochian, LV. (2000): The molecular physiology of heavy metal transport in the Zn/Cd hyper accumulator *Thlaspi caerulescens*. Proc. Nat.l Acad. Sci. U. S. A., **97**: 4956–4960.

Peralta-Videa, J. R.; Gardea-Torresdey, J. L.; Gomez, E.; Tiemann, K. J., Parsons, J. G., Carrillo, G. (2002): Effect of mixed cadmium, copper, nickel and zinc at different pHs upon alfalfa growth and heavy metal uptake. Environ. Pollut., **119**: 291– 301.

Perveen, R.; Faizan, S.; Tiyagi, S. A. and Kausar, S. (2011): Performance of Cd stress condition on Growth and productivity parameters of *Trigonella foenum- graecum* Linn. **7** (5): 607-612.

Prasad, K. V. S. K.; Saradhi, P. P. and Sharmila, P. (1999): Concerted action of antioxidant enzymes and curtailed

References

growth under zinc toxicity in *Brassica juncea*. *Environ. Exp. Bot.*, **42**: 1–10.

Prasad, M. N. V. and Strzalka, K. (1999): Impact of heavy metals on photosynthesis. In heavy metal stress in plants: From Molecules to Ecosystems, eds. M. N. V. Prasad and J. Hagemeyer, 117- 138.

Prokopiev, E. (1978): Afforestation of Industrial Areas. Sofia, Zemizdat, 208.

Rabie, M. H.; Eleiwa, M. E.; Aboseoud, M. A. and Khalil, K. M. (1992): Effect of nickel on the content of carbohydrate and some minerals in corn and broad bean plants. *J. K. A. U. : Sci.*, **4**: 37- 43.

Radic, S.;Babic, M.; Skobic, D.; Roje, V. and Pevalek- Kozlina, B. (2010): Ecotoxicological effects of aluminum and zinc on growth and antioxidants in *Lemna minor L.* *Ecotoxicol. Environ. Saf.*, **73**: 336- 342.

Radotic, K., Ducic, T. and Mutavdzic, D. (2000): Changes in peroxidase activity and isoenzymes in spruce needles after exposure to different concentrations of cadmium. *Environ mental and Experimental Botany* **44**: 105- 113.

Rahmana, H. and Ebrahimzadeh, H (2005): The effect of NaCl on antioxidant enzyme activities in potato seedlings. *Bio. Plant*, **49**: 93- 97.

References

- Rai, V.; Khatoon, S.; Bisht, S. S. and Mehrotra, S. (2005):** Effect of cadmium on growth, ultra morphology of leaf and secondary metabolites of *Phyllanthus amarus* Schum. and Thonn. *Chemosphere*, **61**, 1644- 1650.
- Rai, V.; Vajpayee, P.; Singh, S. N. and Mehrotra, S. (2004):** Effect of chromium accumulation on photosynthetic pigments, oxidative stress defence system, nitrate reduction, proline level and eugenol content of *Ocimum tenuiflorum* L. *Plant Science*, **167**: 1159- 1169.
- Rakhshae, R.; Khosravi, M. and Ganji, M.T. (2006):** Kinetic modeling and thermodynamic study to remove Pb (II), Cd (II), and Zn (II), from aqueous solution using dead and living *Azolla filiculoides*. *J. Haz. Aterials*, **134**: 120– 129.
- Ramelow, G. J.; Fralick, D. and Zhao, Y. (1992):** Factors affecting the uptake of aqueous metal ions by dried seaweed biomass. *Microbios*, **72**: 81– 93.
- Rana Athar and Masood, A. (2002, a):** Heavy metal toxicity: effect on plant growth and metal uptake by wheat, and on free living *Azotobacter*. *Water, Air and Soil Pollution*, **138** (1/4): 165- 180.
- Rana Athar and Masood, A. (2002, b):** Heavy metal toxicity in legume microsymbiont system. *J. Plant Nutr.*, **25**: (2) 369- 386.

References

- Rascio, N.; Vecchia, FD.; Ferretti, M.; Merlo, L. and Ghisi, R. (1993):** Some effects of cadmium on maize plants. Archives of Environment Contamination and Toxicology, **25**: 244-249.
- Richards, L. A. (1954):** Diagnosis and Improvement of saline and Alkali soils. U. S. Dept. of Agric., Hand Book No. 60.
- Rincon, J.; Gonzalez, F.; Ballester, A.; Blazquez, M.L. and Munoz, J. A. (2005):** Biosorption of heavy metals by chemically activated algae *Fucus vesiculosus*. J. Chem. Technol. Biotech., **80**: 1403– 1407.
- Robe, R. and Kreeb, K. H. (1979):** Enzyme activities and chlorophyll and protein content in plants as indicators of air pollution. Environmental Pollution, **19**: 119-137.
- Romera, E.; Gonzalez, F.; Ballester, A.; Blazquez, M. L. and Munoz, J. A (2006):** Biosorption with algae: A statistical review. Crit. Rev. Biotechnol. ; **26**: 223– 235.
- Romera, E.; Gonzales, F.; Ballester, A.; Blazquez, M. L. and Munoz, J. A. (2007):** Comparative study of biosorption of heavy metals using different types of Algae. Biores. Techn., **98**: 3344– 3353.
- Romera, E.; Gonzales, F.; Ballester, A.; Blazquez, M. L. and Munoz, J. A. (2008):** Biosorption of heavy metals by *Fucus spiralis*. Bioresource Technol.; **99**: 4684– 4693.

References

- Roy, S.; Labelle, S.; Mehta, P.; Mihoc, A.; Fortin, N.; Masson, C.; Leblanc, R.; Chateauneuf, G.; Sura, C.; Gallipeau, C.; Olsen, C.; Delisle, S.; Labrecque, M. and Greer, C. W. (2005): Phytoremediation of heavy metal and PAH-contaminated brownfield sites, *Plant and Soil*, **272**: 277-290.
- Samantary, S. (2000): Biological response of chromium tolerant and chromium sensitive Mung bean, cultivars growth on varying level of chromium. *Chemosphere*, **47**: 1065- 072.
- Sandalio, L. M.; Dalurzo, H. C.; Gomez, M.; Romero- Puertas, M. C. and del Rio L. A. (2001): Cadmium- induced changes in the growth and oxidative metabolism of pea plants. *J. Exp. Bot.*, **52**: 2115- 2126.
- Sanjoy, S.; Bandpadhyay, P. K. and Arpita Das. (2010): Changes in the level of protein due to Hg and Cd – poisoning of wheat varieties and its amelioration. *Envir. and Ecol.*, **28** (4): 2268– 2271.
- Sari, A. and Tuzen, M. (2008, a): Biosorption of Pb (II) and Cd (II) from aqueous solution using green algae (*Ulva lactuca*) biomass. *J. Haz. Mater.*, **152**: 302– 308.
- Sari, A. and Tuzen, M. (2008, b): Biosorption of cadmium from aqueous solution by red algae (*ceramium virgatum*): Equilibrium, kinetic and thermodynamic studies *J. Haz. Materials*, **157**: 448-454.

References

- Sarita, S. and Abha, A. (2007):** Differential action of zinc, nikel and cadmium on total chlorophyll content, total nitrogen content and grain yield of wheat (*Triticum aestivum*, Cr. 2425). *Vegetos*, **20** (2): 27– 30.
- Sauter, A. and K. Stoub. (1990):** Official Method of analysis. Association of official analytical chemists, Inc., Suite 400, ARLINGTON Virginia 22201, U.S.A.
- Schlegel, H. G. (1956):** Die Verwertung organischer. Sauren durch in *Chlorella* in Licht. *Planta*.**47**: 510.
- Seheng, P. X.; Ting, Y. P.; chem., J. P. and Hong, L. (2004):** Sorption of lead, copper, cadmium, zinc and nickel by marine algal biomass. Characterization of biosorptive capacity and investigation of mechanisms. *J. Coll. Interf. Sci.*, **275**: 131– 141.
- Seregin, I. V. and Ivanov, V. B. (2001).** Physiological Aspects of Cadmium and Lead Toxic Effects on Higher Plants. *Russ. J. Plant Physiol.*, **4**: 523– 544.
- Shaddad, M. A. K.; Galal, H. R. M. and Hussein, A. A. (2007):** Application of wastewater treatment by algae in irrigation of some economic plants in the field. B- Effect of waste and processed wastewater on antioxidant enzymes and heavy metals content. *N. Egypt. J. Microbiol.*, Vol. **17**.

- Shah, K.; Kumar, R. G.; Verma, S. and Dubey, R. S. (2001):** Effect of cadmium on lipid peroxidation, superoxide anion, germination and activities of antioxidant enzymes in rice seedlings. *Plant Sci.*, **161**: 1135-1144.
- Sharma, D. C.; Chatterjee, C.; Sharma, C. P. (1995):** Chromium accumulation and its effects on wheat (*Triticum aestivum* L. CV. HD 2204) metabolism. *Plant Science*, **111**: 145-151.
- Sharma, D. C. and Sharma, C. P. (1996):** Chromium uptake and toxicity affect on growth and metabolic activities in wheat, *Triticum aestivum* L. cv. UP2003. *Indian J. Exp. Biol.*, **34**:689 - 91.
- Sharma, R. K.; Agrawal, M. and Marshall, F. M. (2006):** Heavy metals contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. *Bull. Environ. Contam. Toxicol.*, **77**: 311- 318.
- Sharma, R. K.; Agrawal, M. and Marshall, F. M. (2007):** Heavy metals contamination of soil and vegetables in suburban areas of Varanasi, India. *Ecotoxicol. Environ. Saf.*, **66**: 258-266.
- Sheng, P. X.; Ting, Y. P.; Chen, J. P. and Hong, L. (2004):** Sorption of lead , copper, cadmium, zinc and nickel by marine algae biomass: characterization of biosorptive capacity and investigation of mechanisms. *J. Colloid Interf. Sci.* **275**(1), 131- 141.

Shukla, U. C.; Singh, J.; Joshi, P. C. and Kakkar, P. (2003): Effect of bioaccumulation of cadmium on biomass productivity, essential trace elements, chlorophyll biosynthesis and macromolecules of wheat seedlings. *Biol., Trace Element Res.*, **92** (3): 257– 273.

Siedlecka, A.; Krupa, Z.; Samuelsson, G.; Oquistand, G. and Gardestrom, P. (1997): Primary carbon metabolism in *Phaseolus vulgaris* plants under Cd(II)/Fe interaction. *Plant Physiol. Biochem.*, **35**: 951- 957.

Singh, A. and Agrawal, M. (2011): Management of heavy metal contaminated soil by using organic and inorganic fertilizers: Effect on plant performance. *The IIOAB Journal Special Issue On Environmental Management For Sustainable Development*, **2**; Issue 1: 22- 30.

Singh, S. and Kumar, M. (2006): Heavy metal load of soil, water and vegetables in periurban Delhi. *Environ. Monit. Assess.*, **120**: 79- 91.

Sinha, S.; Gupta, A. K. and Bhatt, K. (2007): Uptake and translocation of metals in fenugreek grown on soil amended with tannery sludge: involvement of antioxidants. *Ecotoxicol. Environ. Saf.*, **67**: 267-277.

Snedecor, G. W. and Cochran, W. G. (1980): Statistical Methods., (7th ed.). Iowa state Univ. Iowa, USA.

References

- Solanki, R.; Anju; Poonam and Dhankhar, R. (2011):** Zinc and copper induced changes in physiological characteristics of *Vigna mungo* (L.). J. Environ. Bio., **32**, 747- 751.
- Song, Y. F.; Zhou, Q. X.; Xu, H. X.; Ren, L. P. and Gong, P. (2002):** Ecological toxicity of heavy metals in soils acting on seed germination and root elongation of wheat. Chinese J. Applied Ecology, **13** (4): 459– 462.
- Souguir, D.; Ferjani, E.; Ledoigt, G. and Goupil, P. (2011):** Sequential effects of cadmium on genotoxicity and Lipoperoxidation in *vicia faba* roots. Ecotoxicology, **20** (2): 329– 336.
- Sreedevi, S.; Krishnan, P. N. and Pushpangadan. (2008) :** Cadmium induced oxidative stress and antioxidant responses in roots of black gram [*Vigna mungo* (L.) Hepper]. Ind. J. Plant Physiol., **13**, 1- 7.
- Stiborova, M.; Ditrichova, M. and Brezinova, A. (1987):** Effect of heavy metal ions on growth and biochemical characteristics of photosynthesis of barley and maize seedlings. *Biol. Plant.*, **29**: 453-467.
- Stobart, A. K., Griffiths, W. T., Ameen- Bukhari, I. and Sherwood, R. P. (1985):** the effect of Cd^{2+} on the biosynthesis of chlorophyll in leaves of barley. *Phsiologia Plantarum*, **63**: 293- 298.

- Stohs, S. J., Bagchi, D., (1995) :** Oxidative mechanisms in the toxicity of metal ions. *Free Radical Biol. Med.* **18**: 321–336.
- Sudarshana, Sh.; Parmanand, Sh. and Bhattacharyya, A. K. (2010):** Accumulation of heavy metals in wheat (*Triticum aestivum* L.). seedlings grown in soils amended with electroplating industrial sludge. *Communications in soil and plant Analysis*, **41** (21): 2505– 2516.
- Suzuki, Y.; Kametani, T. and Maruyama, T. (2005):** Removal of heavy metals from aqueous solution by nonliving *Ulva* seaweed as biosorbent. *Water Res.*, **39**: 1803– 1808.
- Szöllösi, R.;Varga, I. S.; Erdei, L. and Mihalik, E. (2009):** *Cadmium-induced oxidative stress and antioxidative mechanisms in germinating Indian mustard (Brassica juncea* L.) seeds, *Ecotoxicology and environmental safety*, **72**: 1337 – 1342.
- Szwarc, W.; Skorska, E. and Wegrzecki, A. (2006):** Comparison the response of wheat and oats to nickel in subsoil during the early phase of growth. *Polish J. of Envir., studies*, **15** (24): 195– 198.
- Tandon, P. K. and Gupta, S. (2002):** Effect of cobalt and lead on the growth and metabolism of gram (*Cicer arietinum*) seeds. *Indian J. Agric. Biochem.*, **15**: 55- 58.

References

- Tawfik, K. M. (2008):** A Monitory Field Study at El Saaf - Helwan Faba bean Farms Irrigated by Industrial Waste Water and Polluted Water with Sewage. *J. Applied Sciences Research*, **4**(5): 492- 499.
- Tlustos, P.; Szakova, J.; korinek, K.; Pavlikova, D.; Hanc, A. and Balik, J. (2006):** The effect of liming on cadmium, lead and zinc uptake by spring wheat grown in contaminated soil. *Plant, soil and Envir.*, **52** (1): 16– 24.
- Turner, A.; Lewis, M. S.; Brown, M. T. and shams, L. (2007):** Uptake of platinum group elements by marine macroulga, *Ulva Lactuca*. *Marine chem.*, **105**: 275– 280.
- Upadhyay, R. G.; Brhan; Saleh, K. and Upadhyay, R. K. (2008):** Response of cadmium on germination, seedling growth behaviour and chlorophyll content of wheat (*Triticum aestivum* L.). *Res. On crops*, **9** (2): 500- 501.
- Van Assche, F. V. and Clijsters, H. (1987):** Enzyme analysis in plants as a tool for assessing phytotoxicity of heavy metal polluted soils, *Mededelingen van de Faculteit landbouwwstenschappen Rijksuniversiteit Gent*, **52**: 1819- 1824.
- Van Assche, F. V. and Clijsters, H. (1990):** Effects of metals on enzyme activity in plants. *Plant Cell Environment* **13**:195- 206.

- Vassilev, A.; Berova, M. and Zlatev, Z. (1998):** Influence of Cd^{+2} on growth, chlorophyll content, and water relations in young barley plants. *Biologia Plantarum*, Vol. **41**, No 4, 601- 606.
- Verkleij, J. A. C. and Shat, H. (1990):** Mechanisms of metal tolerance in higher plants in: Shaw AJ(Ed.). Heavy metal tolerance in plant: Evolutionary Aspect. CRC press, Florid., 179- 193.
- Verma, S. and R. S. Dubey, R. S. (2003):** Lead toxicity induces lipid peroxidation and alters the activities of antioxidant enzymes in growing rice plants. *Plant Sci.*, **164**: 645- 655.
- Vijayaraghavan, K.; Jegan, J.R.; Palanivelu, K. and Velan, M. (2004):** Copper removal from aqueous solutions by marine. Green alga *Ulva reticulata*. *Electronic J., Biotech.*, **7**: 61– 71.
- Vijayaraghavan, K.; Jegan, J.; Palanivelu, K. and velan, M. (2005):** Biosorption of copper, cobalt and nickel by marine green algae *Ulva reticulate* in a packed column. *Chemosphere*, **60**: 419– 426.
- Vijayaraghavan, K.; Palanivelu, K. and Velan, M. (2006):** Treatment of nickel containing Electroplating effluents with *Sargassum wightii* biomass. *Process Biotechn.*, **41**: 853- 859.

References

- Vijayaraghavan, K.; Teo, T.T. ; Balasubramanian, R. and Joshi, V.M. (2008):** Application of sargassum biomass to remove heavy metal ions from synthetic multi-metal solutions and urban storm water runoff. (Article in press). J. Haz., Mater., 8824, PP:5.
- Vilar, V. J. P.; Santos, S. C. R.; Martins, R. J. E.; Botelho, C. M. S. and Boaventura, R. A. R. (2008):** Cadmium uptake by algal biomass in batch and continuous (CSTR and packed bed column) adsorbers. Biochem. Eng. J., **42**: 276– 289.
- Volesky, B. and Holan, ZR.(1995):** Biosorption of heavy metals. Biotechnol Prog., **11**: 235- 250.
- Walnöfer, P. R. and Engelhardt, G. (1984):** Schadstoffe, die aus dem Boden aufge nommen warden, In Pflanzetoxicologie (eds. B. Hock & G.F. Elstner), *Bibliographisches*. Institute, Mannheim, 95-117.
- Wang, M. and Zhou, Q. (2005):** Single and joint toxicity of chlorimuron- ethyl, cadmium, and copper acting on wheat *Triticum aestivum*. Ecotoxicol. Environ. Saf., **60**: 169- 175.
- Watnable, F. C. and S. R. Olsen. (1965):** Test of an ascorbic acid method for determining phosphorous in water and NaHCO₃ extracts from soils. J. Soil Sci. Soc. Am. Proc. **29**: 677- 678.

References

- Weiqliang, Li; Khan, M. A.; Yamaguchi, S. and Kamiya, Y. (2005):** Effects of heavy metals on seed germination and early seedling growth of *Arabidopsis thaliana*. *Plant Growth Regulation*, **46**:45– 50.
- Wong, J. P. K.; Wong, Y. S. and Tam, N. F. Y. (2000):** Nickel biosorption by two chlorella species, *C. Vulgaris* (a commercial species) and *C. Miniata* (a local isolate), *Bioresour. Technol.*, **73**: 133- 137.
- Woolhouse, H. W. (1983):** Toxicity and tolerance in the responses of plants to metals. In *Encyclopedia of plant physiology*, 12C: Physiological Plant Ecology III (eds. O.L. Lange,, P. S. Nobel, C. B. Osmond & H. Ziegler).P.p.245-300.
- Wozny, A. and Krzeslowska, M. (1993):** Interaction of toxic metal ions Cd, Hg and Pb with light harvesting protein of chloroplast thylakoid membranes. *J. Inorganic Biochemistry*, **50**: 235- 243.
- Yang Yingli; Wei, Xu.; Lu, J.; You, J.; Wang, W.R. and shi, R.X. (2010):** Lead – induced phytotoxicity mechanism involved in seed germination and seedling growth of wheat (*Triticum aestivum* L.). *Ecotoxicology and Envir., Safety*, **73** (8): 1982– 1987.

References

- Yang Yingli; Zhang, Y. Y.; Wei, Xu.; You, J.; Wang W. R.; Lu, J. and Shi, R. X. (2011):** Comparative antioxidative responses and proline metabolism in two wheat cultivars under short term lead stress. *Ecotoxicology and Envir., safety*, **47** (4): 733– 740.
- Yun, Y. S.; Parck, D.; Park, J. M. and volesky, B. (2001):** Biosorption of trivalent chromium on the brown seaweed biomass. *Envir. Sci., and Techn.* **35**: 4353– 4358.
- Zein, F. I.; Amou, M. Z. A.; El-Leithi, A. A. and El-Shami, M. M. (2002):** Effect of polluted irrigation water on some crops and their contents of heavy metals. 1– wheat. *Egypt. J. Soil, Sci.*, **42** (1): 139– 159.
- Zengin, F. K. and Munzuroglu, O. (2005):** Effects of some heavy metals on content of chlorophyll, proline and some antioxidant chemicals in bean (*Phaseolus vulgaris* L.) seedlings. *Acta Boilologica cracoviensia series Botanica*, **47** (2): 157– 164.
- Zhangren, N.; Chuanyan, Z.; Li, Ji.; chen, F. and Sun Wu. (2002):** Relations between soil properties and selected heavy metal concentrations in spring wheat (*Triticum aestivum* L.) grown in contaminated soils. *Water, Air and soil pollution*, **133** (1/4): 205– 213.