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ASSESSMENT OF ENVIRONMENTAL POLLUTION OF WATER FROM IRRIGATION CANAL (ALEKSANDROVAČKI CANAL, SERBIA) USING PHYTO-INDICATORS

S. Gvozdenac, D. Inđić, S. Vuković, V. Bursić and J. Tričković*

[1]Faculty of Agriculture, University of Novi Sad, 21000 Novi Sad, Serbia
[2]Faculty of Science, University of Novi Sad, 21000 Novi Sad, Serbia
Corresponding author email: sonjag@polj.uns.ac.rs

ABSTRACT

The aim of this study was to carry out comparative assessment of pollution level of water from Aleksandrovački canal, Serbia, using both chemical methods and phytoindicators, and to estimate its potential use for irrigation of four most commonly cultivated plant species in this area (maize, barley, cucumber and white mustard). The effect of water quality and/or pollution was assessed in bioassay, according to changes in physiological (seed germination energy, germination) and morphological parameters (root and shoot length -cm and fresh and dry weight of root and shoot-g) of tested species. The chemical analysis of water determined a high content of suspended substances, nutrients, ammonium ion, total nitrogen, organic matter with low degradability, total organic carbon, orthophosphates, total phosphorus, arsenic and chromium. The response of phyto-indicators to water quality and mixed pollution was species-dependant. Germination of maize, cucumber and white mustard was not under the influence of water quality, while barley seeds germinated in significantly lower percentage in water from the canal (95%) compared to the control (100%). Canals water inhibited root elongation of maize and barley and stimulated of white mustard ($p<0.01$) compared to the control. Shoot length of barley, cucumber and white mustard was not under the influence of water quality ($p>0.05$). Biomass was differently affected by water from the canal.

Key words: Canal water, pollution, irrigation, plants, bioindicators

INTRODUCTION

Inappropriate and frequent use of agrochemicals (pesticides and mineral fertilizers) and a discharge of untreated industrial effluents and sewage directly into the water reservoirs have led to contamination of water sources (Ashraf *et al.*, 2008, Prica *et al.*, 2010) including irrigation canals. This problem is more pronounced in industrial and agricultural regions, where water from canals is polluted with a variety of compounds, often has reduced level of dissolved oxygen and high nutrients content (Emmanuel *et al.*, 2012), as well as pesticide residues originating from fields drainage (Schulz and Liess 1999). Generally the use of such water for irrigation, although benefits to farmers due to reduced costs, can be harmful for ecosystem (Ashraf *et al.* 2008), cause phyto-toxic effects and affect crop production (Schulz and Liess 1999). The occurrence of toxic effect on growth and development of cultivated crops after a long-term irrigation with water containing high levels of toxic substances was also reported by Liu *et al.* (2005). In terms of toxicity assessment, the use of water from irrigation canals presents a complex situation due to possible interactions between pollutants and plants. Therefore, to estimate the water quality and decide if it can be used for irrigation of certain crops it is necessary to perform a comparative study using both, chemical and biological methods for risk assessment. Biological tests that include agricultural plants as indicators of contamination have become a useful tool for the evaluation of quality of water that is used for irrigation in the last few years and for risk assessment of different organic and inorganic pollutants (Casa *et al.* (2003); Leitgib *et al.* (2007); D'Aquino (2009); Schultz *et al.* (2010); Gvozdenac *et al.* (2011)).

Aleksandrovački canal, Serbia, has been contaminated with a variety of compounds originating from industrial and domestic effluents and agricultural products from field drainage waters (pesticides and fertilizers run off). According to a long term monitoring it is considered extremely polluted, but it is still intensively used for irrigation of crops without thought of potential phytotoxic effects. Therefore, the aim of this study was to evaluate the quality and/or the level of pollution of water from this canal in comparative analysis using chemical and biological methods –plants as indicators, and to assess its suitability for irrigation of four most commonly cultivated plants (maize, barley, cucumber and white mustard) in this area.

MATERIALS AND METHODS

Water from Aleksandrovački canal was collected in 2011 at site N 45° 20.912' / E 20° 25.032'. Analyzed parameters of water quality and methods used for chemical analysis are presented in Table 1.

For bioassay, test species were chosen as the most commonly cultivated plants in this area– maize (*Zea mays* L.) variety NS 6030, barely (*Hordeum vulgare* L.) variety Novosadski 525, cucumber (*Cucumis sativus* L.) variety Tajfun and white mustard (*Sinapis alba* L.) variety Torpedo. The effect of water quality on plants was evaluated according to changes in physiological (seed germination energy, germination - %) and morphological parameters (root and shoot length -cm and fresh and dry weight of root and shoot -g).

Bioassay was carried out according to a standard filter paper method described by International Seed T Association: International Rules for Seed Testing- ISTA (2011). For germination assessment, 50 maize and 100 barely, cucumber and white mustard seeds were placed in plastic boxes on pleated filter paper, previously moistened with 25 mL of sampled water from the canal and distilled water for the control variant. Seeds were incubated in dark at 25±2 °C for three (white mustard) or four days (other species) after which 10 seedlings were taken from each replicate and placed on filter paper lane (14 x 60cm) previously moistened with 30ml of tested water sample, rolled up, packed in PVC bags and placed back in thermostat. Boxes with remained seeds were also returned in thermostat until the final germination assessment. After seven (maize, barley and white mustard) and eight (cucumber) days germination was recorded and length of seedlings roots and shoots and their fresh weight were measured. After the drying to the constant mass, the dry weight was also measured. Experiment was set in four replicates.

Data were analyzed using T test, for 95% confidence interval, in software SPSS version 17.0 (SPSS, Inc., Chicago IL).

RESULTS AND DISCUSSION

Chemical analysis: The chemical analysis of water from Aleksandrovački canal and classification according to Regulation on limit values for pollutants in surface and ground waters and sediments (Official gazette RS, 50/12) are presented in Table 1. Maximal allowable concentrations (MAC) used as limit values are for the III class of water according to the mentioned Regulation, because, respecting national directives only I, II and III class of water can be used for irrigation without prior treatment.

Chemical analysis detected high levels of: COD, BOD_5, organic matter with low degradability (COD/BOD_5 ratio 5.7) which results in almost total absence of oxygen, high conductivity, suspended substances, total nitrogen, ammonium ion, orthophosphates, total phosphorus, TOC, arsenic and chromium.

Bioassay: The results of bioassay, presented in Table 2, indicate that germination and seedlings early growth were differently affected by total chemistry of the water from Aleksandrovački canal and mixed pollution. This is in accordance with findings of Liu (2005) that tolerance levels of crops are species-dependant and vary under different stress intensities (concentrations and type of pollutants) and growth stages.

Germination of maize, cucumber and white mustard (F=0.70ns, 1.03ns, 1.77ns, P>0.05, respectively) was not under the influence of water quality. This is in accordance with previous reports of Gvozdenac *et al.* (2011, 2012) indicating that germination of maize and cucumber was not affected by the chemical composition of canal water containing elevated levels of organic nitrogen, ammonium ions, nitrates, nitrites, orthophosphate and total phosphorus as well as total organic carbon, cadmium, copper and nickel. On the other hand, germination of barley seeds was significantly inhibited in water from Aleksandrovački canal compared to the control ($F=2.61^{*}$, P<0.05). This can be result of mixed pollution of water sample from the canal, or a specific component. According to some researchers high electrical conductivity, indicating at high salt content, increases osmotic pressure which causes germination retardation due to reduced available water content or toxicity of specific ions (Sheoron and Grag (1980); Ramana *et al.* (2002); Samuel and Muthukkaruppan (2012); Mehta and Bhardwaj (2012)). According to Pandey *et al.* (2007) this effect varies from crop to crop because each has its own tolerance to different salt concentrations. High COD and BOD_5 can also cause inhibition of germination as reported by Samuel and Muthukkaruppan (2012) for rice and Mehta and Bhardwaj (2012) for *Vigna radiata* and *Cicer arientinum*. The reduction of germination can be also due to the presence of high levels of detected heavy metals in water from the canal. As reported by Talukdar (2011), Aresnic (30 and 40 mg/L) can effect germination of *Trigonella foenum-graecum* L. and *Lathyrus sativus* L. Also, Cr in amounts exceeding 500ppm decreased germination of beans by 48% (Parr and Taylor 1982), of beet root by 32-57% (20-80ppm) (Jain *et al*., 2000), and of alfalfa seed by 23% at rates 40ppm (Peralta *et al.*, 2001).

Root elongation of maize and barley ($F=3.64^{**}$, 5.43^{**}, P<0.01), was highly significantly inhibited by water from Aleksandrovački canal. On the other hand, some specific synergistic effect of all compounds from the water sample on seedlings root growth of white mustard was recognized since it was significantly stimulated by water ($F=11.92^{**}$, P<0.01). Cucumber seedlings root (F=0.26 ns, P>0.05) was not under the influence of water quality. A number of authors reported different effects of irrigation water on root length. Schier (1985) and Wong and Chu (1985) pointed out that different plants show significant reduction in growth parameters when irrigated with polluted water. Also, according to Gvozdenac *et al.* (2012) root elongation of maize, cucumber and barley were inhibited by interstitial water contaminated with Cr. Also, Mehta and Bhardwaj (2012) found that water rich in BOD and COD as well as total dissolved solids significantly reduced seedlings growth of *Vigna radiata* and *Cicer arientinum.* Potential effect of heavy metal pollution of water from Aleksandrovački canal on tested species should be also recognized. This is in accordance with Liu *et al.* (2007) who detected a reduction in root length as a result of As-induced toxicity (5-20 mg/kg) and of Barcelo *et al.* (1986); Barton *et al.* (2000); Chen *et al.* (2001) indicating that Cr, also detected in high content in this work, is potential cause for root inhibition of cultivated plants. The opposite results indicating a positive effect of mixed water pollution are presented by several authors. Gafoor *et al.* (1994) reported that irrigation water containing plant nutrients and organic matter, high concentration of soluble salts and heavy metals can stimulate growth of a number of plant species. Also, waste water containing nutrients of fertilizing value, especially nitrogen, can enhances plant growth and yield of crop plants (Soumare *et al.* (2003); Gupta *et al.* (2005); Afroza *et al*. (2008)), which was also proved in our work for white mustard.

Table 1. General parameters and heavy metal content in water from Aleksandrovački canal

Surface water				
Parameter	**Method**	**Values***	**MAC for III class**	**Class based on detected values**
COD	ISO 6060:1994	**332**	20	**V**
BOD_5	H1.002	**58**	7	**V**
Diluted oxygen		0.8	5	II
pH		7.83	6.5 - 8.5	II
conductivity		**3150**	1500	**V**
Suspended substances	APHA 2540D	**161**	25	
Dry residue	APHA 2540B	1430	-	
Residue on ignition	APHA 2540E	869	-	
Loss on ignition	calculate	557	-	
Total nitrogen	calculate	**80.1**	8	**V**
Organic nitrogen	EPA 351.3	73,9	-	
Ammonium ion	APHA 4500-NH_3 C:1989	**5.99**	0.6	**V**
Nitrates	ISO 7890-3:1994	0.136	6	I
Nitrites	ISO 6777:1997	0.099	0.12	III
Orthophosphates	EPA 365.3	**3.95**	0.2	**V**
Total phosphorus	EPA 365.3	**6.98**	0.4	**V**
TOC	EPA 415.3	**186**	15	**V**
Sulphates		74.3	200	II
Arsenic	EPA 7010	**32.3**	10	**IV**
Cadmium	EPA 7010	< 0.15	1	< MAC-EQS
Chromium	EPA 7010	**1330**	100	**V**
Copper	EPA 7010	50	500	II
Lead	EPA 7010	< 5	5	no MAC-EQS
Mercury	EPA 7010	< 0.17	0.1	< MAC-EQS
Nickel	EPA 7010	< 1.1	50	no MAC-EQS
Zinc	EPA 7000b	< 11	30	I
Iron	EPA 7010	460	500	II
Manganese	EPA 7010	79	100	I

*all values are expressed in µg/L; MAC values are for the III class according to Regulation on limit values for pollutants in surface and ground waters and sediments (Official gazette RS, 50/12); Values in bold exceed maximal permissible limits

Shoot length of barley, cucumber and white mustard seedlings (F=0.58 ns, 0.27 ns, 2.44 ns, P>0.05, respectively) were not under the influence of water quality and/or mixed pollution, which was also reported by a number of researchers (Schulz and Liess 1999, Gvozdenac *et al.* 2011, 2012) while maize shoot was stimulated by water from Aleksandrovački canal ($F=2.95^{**}$, P<0.01). According to Marshner (2002) water rich in essential elements like nitrogen can enhance seedlings growth when used for irrigation.

Fresh root weight of maize, barley and white mustard seedlings was not under the influence of water quality and/or mixed pollution (F=0.91 ns, 0.14 ns, 0.89 ns, P>0.05, respectively), while cucumber seedlings weight was stimulated by water from the canal (F=12.23**, P>0.05). Dry weight of root was inhibited by water only in the case of white mustard (F=6.54**, P<0.01) while values for maize, barely and cucumber were on the same level of significance with the control (F=4.23 ns, 1.29 ns, 0.00 ns, P>0.05, respectively). Fresh weight of shoots of all testes plant species (F=3.15**, 2.45*, 4.56*, 3.89*, P<0.05/>0.01) was significantly stimulated by water from the canal as well as dry weight of maize, cucumber and white mustard shoots (F=5.13**, 21.24*, 8.97*, P<0.05/>0.01) compared to the control. The results of Marshner (2002) and Afroza *et al.* (2008) indicate that high levels of nitrogen enhance growth parameters like plant fresh and weight dry weight. The inhibition of dry weight of white mustard seedlings in our work may also be due to the presence of certain heavy metals. As presented by Kocik and Ilavsky (1994), cabbage plants cultured under Cr (10 ppm) exhibited a reduction in dry weight. However, Hara and Sonoda (1979) presented different results that Cr did not affect dry mass quality and quantity of sunflower, wheat and *Vicia fabea* even in amounts 200mg/L.

Table 2. Physiological and morphological parameters of tested plant species

Parameters	Sample	maize	barley	cucumber	white mustard
germination (%)	water	97.0 ±3.83 a	95.0 ±3.83 b	96.0 ±4.62 a	78.0 ±5.35 a
	control	98.5 ±1.91 a	100.0 ±0.00 a	93.0 ±3.46 a	83.3 ±2.50 a
	t value	**0.70 ns**	**2.61***	**1.03 ns**	**1.77 ns**
root length (cm)	water	12.70 ±2.95 b	12.62 ±1.03 b	8.44 ±1.39 a	6.60 ±0.22 a
	control	18.08 ±0.06 a	15.86 ± 0.60 a	8.78 ±2.15 a	3.51 ±0.41 b
	t value	**3.64****	**5.43****	**0.26 ns**	**11.92****
fresh root weight	water	6.31 ±1.40 a	1.37 ±0.33 a	0.89 ±0.21 a	0.012 ±1.65 a
	control	6.24 ±0.61 a	1.47 ±0.13 a	0.28 ±0.19 b	0.011 ±0.32 a
	t value	**0.91 ns**	**0.14 ns**	**12.23****	**0.89 ns**
dry root weight	water	0.485 ±0.108 a	0.177 ±0.059 a	0.048 ±0.34 a	0.01 ±1.44 b
	control	0.488 ±0.047 a	0.192 ±0.029 a	0.048 ±0.10 a	0.09 ±0.87 a
	t value	**4.23 ns**	**1.29 ns**	**0.00 ns**	**6.54****
shoot length (cm)	water	7.12 ±0.75 a	12.43 ±1.40 a	12.05 ±1.52 a	5.52 ±0.03 a
	control	5.74 ±0.55 b	12.98 ±1.65 a	12.29 ±0.88 a	4.04 ±1.00 a
	t value	**2.95 ****	**0.58 ns**	**0.27 ns**	**2.44 ns**
fresh shoot weight	water	3.92 ±0.12 a	2.18 ±2.12 a	5.97 ±1.12 a	0.074 ±0.23 a
	control	1.72 ±1.45 b	1.36 ±1.76 b	3.10 ±0.12 b	0.047 ±1.66 b
	t value	**3.15****	**2.45***	**4.56***	**3.89***
dry shoot weight	water	0.32 ±2.12 a	0.17 ±3.10 a	0.30 ±2.16 a	0.056 ±1.45 a
	control	0.18 ±1.87 b	0.17 ±2.12 a	0.21 ±1.00 b	0.039 ±3.12 b
	t value	**5.13****	**0.00 ns**	**21.24***	**8.97***
root/shoot	water	1.80	1.02	0.71	0.83
	control	3.17	1.24	0.71	1.10

T test ±SD; values with the same letter in the column are on the same level of significance for the confidence interval 95%; **p<0.01;* p<0.05; NS p>0.05

Recommendation: Based on the results of comparative study on the quality of water from Aleksandrovački canal, some parameters of chemical analysis indicate that it is very polluted (IV, V class). Also a certain phyto-toxic effect was registered on tested crop species, therefore the water from this canal is not recommended to be used for irrigation unless previously treated.

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REFERENCES

Afroza, A., A. Inam and A. Inam (2008). Response of mustard and linseed to thermal power plant wastewater supplemented with nitrogen and phosphorus. African J. Plant Sci. 2 (8): 067-071.

Ahsan, N., D.G. Lee, S.H. Lee, K.Y. Kang, J.J. Lee, P.J. Kim, H.S. Yoon, J.S. Kim and B.H. Lee. (2007). Excess copper induced physiological and proteomic changes in germinating rice seeds. Chemosphere. 67(6): 1182-1193.

Ammonia was determined by spectrophotometric method after distillation (nesslerization method) (APHA 4500-NH_3 C, 1989).

APHA 2540B. Total Solids Dried at 103–105°C. Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Washington DC, 17th Edition, 1989.

APHA 2540D. Total Suspended Solids Dried at 103–105°C. Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Washington DC, 17th Edition, 1989.

APHA 2540E. Fixed and Volatile Solids Ignited at 550°C. Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Washington DC, 17th Edition, 1989.

APHA 4500-NH_3 C. Nesslerization method (Direct and Following Distillation). Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Washington DC, 17th Edition, 1989.

Ashraf, M.A., J.M. Mohd, Y. Ismail and M. Karamat (2008). Effects of polluted water irrigation on environment and health of people in Jamber, District Kasur, Pakistan. International J.Basic & Applied Sciences IJBAS-IJENS. 10(3): 37-57.

Barcelo, J., C. Poschenrieder and B. Gunse (1986). Water relations of chromium VI treated bush bean plants (*Phaseolus vulgaris* L. cv contender) under both normal and water stress conditions. J. Exp. Bot. 37:178–187.

Barton, L.L., G.V. Joshnson, A.G. O'Nan and B.M. Wagener (2000). Inhibition of ferric chelate reductase in alfalfa roots by cobalt, nickel, chromium and copper. J Plant Nutr. 23: 1833-1845.

Biochemical Oxygen Demand was determined by standard manometric method (WTW Lovibond BOD analyzer). (H1.002)

Casa, R., D. Annibale, F. Pieruccetti, S.R. Stazi, G. Giovannozzi Sermanni and B. Lo Cascio (2003). Reduction of the phenolic components in olive-mill waste water by an enzyatic treatment and its impact on durum wheat (*Tricum durum* Desf.) germinbility. Chemosphere. 50: 959-966.

Chen, N.C., S. Kanazawa, T. Horiguchi and N.C. Chen (2001). Effect of chromium on some enzyme activities in the wheat rhizosphere. Soil Microorg. 55: 3-10.

D'Aquino, L., M. Concetta de Pinto, L. Nardi, M. Morgana and F. Tommasi (2009). Effect of some light rare earth elements on seed germination, seedling growth and antioxidant metabolism in *Triticum durum*. Chemosphere. 75: 900–905.

Emmanuel J., G. Joshua and B. Shams (2012). Comparative study of four wetlands of Punjab using macroinvertebrates as bioindicators. The J. Anim. and Plant Sci., 22 (4): 908-914.

EPA 351.3, Nitrogen, Kjeldahl, Total (Colorimetric; Titrimetric; Potentiometric).

EPA 365.3, Phosphorous, All Forms (Colorimetric, Ascorbic Acid, Two Reagent).

EPA 415.3, Determination of total organic carbon and specific UV absorbance at 254 nm in source water and drinking water, 2003.

EPA 7000b. FLAME ATOMIC ABSORPTION SPECTROPHOTOMETRY. US Environmental Protection Agency, 2007.

EPA 7010. GRAPHITE FURNACE ATOMIC ABSORPTION SPECTROPHOTOMETRY. US Environmental Protection Agency, 2007.

Gafoor, A., A. Rauf, M. Arif and W. Muzaffar (1994). Chemical composition of effluents from different industries of the Faisalabad Pakistan. J. Agri. Sci. 33:73-74.

Gupta, L., N.A. Khan and S. Singh (2005). Growth, photosynthetic traits and activities of antioxidative enzymes of municipal waste water-treated cabage (*Brassica oleracea* L.). J. Plant Biol. 31: 1-4.

Gvozdenac S., D. Inđić, S. Vuković, M. Grahovac, M. Vrhovac, Ž. Bošković and N. Marković (2011). Germination, root and shoot length as indicators of water quality. Acta Agriculturae Serbica, 16: 33-41.

Gvozdenac, S. and D. Inđić (2012). International Conference on BioScience: Biotenology and Biodiversity- Step in the Future The Forth Joint UNS-PSU Conference, 331-341.

Hara, T. and Y. Sonoda (1979). Comparison of the toxicity of heavy metals to cabbage growth. Plant Soil. 51: 127– 133.

International Seed T Association: International Rules for Seed Testing. ISTA. Switzerland (2011).

ISO 6060: (1989), Water quality -- Determination of the chemical oxygen demand

ISO 6777: (1984), Water quality -- Determination of nitrite -- Molecular absorption spectrometric method.

ISO 7890-3:1988, Water quality – Determination of nitrate – Part 3: Spectrometric method using sulfosalicylic acid.

Jain, R., S. Srivastava and V.K. Madan (2000). Influence of chromium on growth and cell division of sugarcane. Indian J. Plant Phisiol. 5: 228-231.

Kocik, K. and J. Ilavsky (1994). Effect of Sr and Cr on the quality of the biomass of field crops. Production and utilization of agricultural and forest biomass of energy: Proceeding of a seminar held at Zvolen, Slovakia, 168-178 p.

Leitgib, L., J. Kalman and K. Gruiz (2007). Comparison of bioassays by testing whole soil and their water extract from contaminated sites. Chemosphere. 66: 428-434.

Liu X., Sh. Zhang, X. Shan and Y. Zhu (2005). Toxicity of arsenat and arsenit on germination, seedling growth and amylolytic activity of wheat. Chemosphere. 61: 293-301.

Marshner, H. (2002). Mineral nutrition in higher plants. London Academic Press

Mehta A. and N. Bahardwaj (2012). Phytotxic effect of industrial effluents on seed ger ination and seedling of *Vigna radiata* and *Cicer arientinum*. Global J. Bio-Science and Biot. 1: 1-5.

Pandey S., P. Tyagi and A. Gupta (2007). Physio-chemical analysis and effect of distillery effluent on seed germination of wheat (*Triticum aestivum*) and lady`s finger (*Abelomoschus esculentus*). ARPN J. Agri. and Biol. Sci. 2: 35-40.

Parr, P.D., and Jr. F.G. Taylor (1982). Germination and growth effects of hexavalent chromium in Orocol TL (a corrosion inhibitor) on *Phaseolus vulgaris*. Environ. Int. 7: 197-202.

Peralta, J.R., J.L. Gardea Torresdey, K.J. Tiemann, E. Gomez, S. Arteaga and E. Rascon (2001). Uptake and effects of five heavy metals on seed germination and plant growth in alfalfa (*Medicago sativa* L.). B Environ. Contam. Toxicol. 66(6): 723-734.

Prica, M., B. Dalmacija, M. Dalmacija, J. Agbaba, D. Krčmar, J. Tricković and E. Karlovic (2010). Changes in metal availability during sediment oxidation and the correlation with immobilization potential. Ecotoxicology and Environmental Safety. 73 (6): 1370-1377.

Ramana, S., A.K. Biswas, S. Kundu, J.K. Saha and R.B.R. Yadava (2002). Effect of distillery effluent on seed germination in some vegerable crops. Bioresource Technology. 82: 273-275.

Regulation on the limit values for pollutants in surface and ground waters and sediments, (Official gazette RS 50/12) (2012).

Samuel, S. and S.M. Muthukkaruppan (2011). Physio-chemical analysis of sugar mill effluent, contaminated soil and effect on seeg dgerminatrion of paddy (*Oryza sativa* L.). International J. Pharmaceutical and Biol. Archives. 2 (5): 1469-1472.

Schier, G.A. (1985). Response of red spruce and blasam fir seedlings to aluminium toxicity in nutrient solutions. Can. J. Forest Res. 15: 29-33.

Schulz, R. and M. Liess (1999). A field study of the effects of agriculturall derived insecticide input on stream macroinvertebrate dynamics. Aquat. Toxicol. 46: 15-76.

Sheoron, I.S and O.P. Grag (1980). Effects of C1 and SO4 salinity on germination and early seedlings growth of mong (*Phaseolus aureus*). Acta botanica Indica. 6: 84-89.

Talukdar D. (2011). Effect of arsenic-induced toxicity on morphological traits of *Trigonella foenum-graecum* L. and *Lathyrus sativus* L. during germination and early seedling growth. Current Research J. Biol. Sci. 3: 116–123.

Wong, M.H. and L.M. Chu (1985). The responses of edible crops treated with extracts of refuse compost of different ages. Agic. Wastes. 14: 63-74.