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Eco-Physiological Impact of Solid Waste of a Chor-Alkali Industry on the Seed Biology of a Crop Plant and Possible Reclamation of the Waste by Phytochemicals

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Abstract

The Chlor-alkali industry located on the river bank discharges its waste into the river directly / indirectly. It was observed that the solid waste contained significant amount of mercury much more than prescribed limit. The lechate and washings from the solid waste dumping site enter into the river during rainy season increasing the mercury level in the river water. This river water was used to irrigate the crop fields at down stream which contaminated the crop fields. The solid waste analysis indicated the highly toxic nature of the waste containing significant amount of mercury. The seed germination and seedling establishment decreased significantly in the solid waste exposed pots with the increase in solid waste (containing mercury) concentration, when compared to the respective control values. The pigments like total chlorophyll and total pheophytin content significantly decreased in exposed seedling leaves compared to control seedling leaves of the crop seedlings. Four plants were selected based on their economic importance. The leaf extracts were used for the experiments to find out a possible solution for reclamation of the solid waste. In the experimental pots, along with solid waste, 10ml of the plant extract was applied for consecutive 5days in each petripot. It was observed that the phytochemicals extracted from both *Calotropis* and *Jatropha* could not support reclamation rather further deterioration was observed. But in case of *Azadirachta* and *Oscimum* leaf extract 100% recovery was not observed. The observed values were much less than the control value. No significant improvement in seed germination or seedling growth was noted in solid waste exposed pots. However, we can conclude that application of both *Azadirachta* and *Oscimum* can support crop improvement. As *Azadirachta* leaf extract can be used as biopesticide instead of synthetic chemical application. The leaf extracts negates the impact of solid waste insignificantly but can be considered as a viable option for reclamation studies. Mercury contained in the solid waste is highly toxic and should not be released into the environment as the toxicant severely affects the environment and the crop plants.

Keywords: Chlor-alkali industry, solid waste, Mercury, crop plant, seed biology, Phytochemicals, pigments.

Introduction

The Chlor-alkali industry at Ganjam, Odisha was established in 1962 and started manufacturing caustic soda, liquid chlorine and hydrochloric acid by using a sheet of elemental mercury as a mobile cathode for the electrolysis of brine water (saturated sodium chloride solution) since August 1967. In the process of manufacture of chemicals the factory discharges the effluent containing mercury and chlorine, into the estuary and deposits solid waste (brine mud, enriched with mercury) on the adjacent land areas. The effluent coming out from the washings of the cells, cell house, hydration chamber and compression chamber contains spilled mercury and left out mercury along with mud, contained huge amount of mercury. This mud and sediments in the effluent canal and effluent treatment and settling tanks of the industry contains significant amount of mercury. Periodically, the sediment of the effluent canal and settling tanks were removed and dumped nearby, which contained huge amount of mercury. During electrolysis high temperature in cells, evaporates mercury and evaporated mercury escapes along with the air of the cell house through exhausts and spreads all over the area and mercury after getting cooled naturally settles on allover the places, settles on plants, settles on aquatic bodies and terrestrial land mass. During rainy season, these settled mercury escapes into water bodies which ultimately reaches river Rushikulya through drainages. After electrolysis, the Sodium-mercury amalgam is transferred to hydration chamber, where water is added with force for mixing. Sodium reacts vigorously with water to form Sodium hydroxide and hydrogen gas is released. Hydrogen gas is transferred to the compression chamber for further reaction with chlorine gas to form HCl acid. After hydration process is complete, sodium hydroxide is removed and the sediment waste comes out during washing of the hydration chamber which contains huge amount of mercury. This effluent waste passes through the effluent canal and reaches the treatment tank and settling tank before the effluent is discharged outside. The sediment waste containing mercury is periodically removed and dumped outside nearer to the River Rushikulya bank. During electrolysis, the evaporated mercury also escapes along with chlorine gas and carried to the compression chamber, where chlorine gas reacts with hydrogen gas coming from hydration chamber under high pressure to form HCl acid and mercury settles in the compression chamber which escapes during washing from the compression chamber as waste. Mercury is thus, discharged into the environment through effluent and solid waste routes, contaminating the adjacent aquatic and terrestrial ecosystems, respectively. This addition of mercury into the environment by effluent discharge and solid waste dump outside the industry is the primary contamination. Initially the effluent was discharged directly into the river but later the effluent was stored in a separate effluent stocking pond from where the effluent leaches into the river and also the effluent is periodically discharged into the river. During rainy season the run off water and flood water carries the whole solid waste and effluent into the river. All the solid waste dumped out side the industry campus is washed during rainy season and enters the river as run off water and in addition during flood, the entire solid waste dumped outside is carried into the river, later to the estuary and finally to Bay of Bengal. The secondary contamination occurs through the chimney into the atmosphere and its fall out by the process of precipitation. All these discharges collectively seem to cause a major environmental threat. The present study was planned to study the impact of mercury contained solid waste on the seed biology of a crop plant and possible reclamation of the waste by using select plant leaf extracts.

Materials & methods

Industry under study:

(Location of industry GPS map, discharge of solid wastes, solid waste dumping site near the industry, solid waste dumped on the river bank of Rushikulya River.)

The Chlor-alkali industry M/S Jayashree Chemicals Pvt. Ltd., was situated on the side of earlier National Highway-5 and at present NH-16 at Ganjam. The industry is located very close to Ganjam Township, district Ganjam, Odisha state, India. The industry is located on the Bank of River Rushikulya discharging its waste into the river directly (initially) and nearer to Rushikulya estuary and about 1.5 km away from the sea, Bay of Bengal on the East and 30 km North of Berhampur city on the south-eastern side of India at 84^0 53'E longitude and 19^0 16'N latitude.

The physico-chemical property of the solid waste was analyzed following the protocols of APHA (1995). The sediment and solid waste collected from the site were air dried and ground to powder in a grinder. The dried solid waste samples were weighed in a monopan electric balance and digested in a Bethge's apparatus with an acid digestion mixture (Wanntorp and Dyfverman, 1955) and amount of mercury was .determined by a Mercury Analyser following ECIL (1981) manual. Pure line healthy seeds of *Vigna radiata*, (L) Wilczek were collected Rice Research Station located at, Pulse and Cereal Research Centre, OUAT, Ratanpur (OUAT, Bhubaneswar) Ganjam, Odisha for the experimental work. *Vigna radiata*, (L) Wilczek was selected for the study, as most of the farmers of the area cultivate this cereal crop as the second phase cultivation after rice crop. The seeds were soaked with different concentrations of test solution from 12h to 48hrs. After scheduled period of exposure, the seeds were washed with tap water, followed by distilled water and their viability was tested according to the procedure of Moore (1969). To calculate the percentage of germination, periodical observations were made at an interval of 24 hours from 48 hours to 144 hours. First emergence of coleorrihza (Referred as Root) about 2 mm. in length was considered as normal germination, so also appearance of coleoptile (Referred as Shoot) before emergence of coleorrhiza was considered as abnormal germination. From this pilot test, a range was selected by visual screening and percentage of germination and percentage of seedling establishment was noted. The seeds were allowed to grow in Petri dishes in growth chamber. Visual screening was carried out basing on the growth and the percentage of seed germination and percentage of seedling establishment was also calculated. The sediments of the Chlor-alkali industry is periodically removed from the effluent canal and dumped as heaps by the side of the effluent canal that runs down to meet the river Rushikulya located nearby. Neither these solid wastes were processed nor treated to remove the toxic pollutants before they were discharged into the environment. The Chlor-alkali industrial solids wastes are one of the direct sources of mercury contamination as it has been seen that surface horizons of sludge-amended soil are enriched in trace elements. The samples to be analyzed for our experimental purpose were collected from different solid waste dumping sites near the caustic-chlorine industry and carried to the laboratory for analyses. Twenty samples from each spot were collected and brought to the laboratory in plastic gunny bags. These were air dried in field conditions for 72 hours. It was then powdered and sieved manually and was subjected to analysis for various important constituents. Four economically important plants were selected and the fresh leaves were collected. The leaves were washed initially with tap water to remove any adhered dust particles and again the leaves were washed with double distilled water. The leaves were dissected carefully and mid rib and veins were removed. Ten grams of processed leaves were homogenized with 100ml of distilled water and the paste is sieved through a net to get the plant leaf extract. The plant leaf extract was kept in the refrigerator covered by aluminum foil for use. Four plants were selected basing on their economic importance and use by human beings for different purposes. The leaf extract of *Azadirachta* leaf and *Oscimum* leaf was used by the farmers in the past to control pests in the crop fields. In addition we have used two other plants like *Jatropha* seeds famous as biofuel and *Calotropis* leaf known for gum and resin production and the dried leaf powder used for plant protection. 1. *Azadirachta* leaf; 2. *Oscimum* leaf, 3.*Jatropha* leaf and 4.*Calotropis* leaf.

Experiments were conducted in Petri pots. Always 10 no. of seeds and 10ml plant leaf extract solutions were utilized for single treatment. After treatment the seeds were taken out and then these were further allowed to dry on a blotting paper at room temperature and in shade condition. Garden soil was collected air dried, powdered and UV irradiated. Decomposed cow dung was collected and air dried, powdered and UV irradiated. A mixture of 1:1 garden soil and cow dung was prepared and stocked for soil setting. This mixture was taken after 7 days of soil mixture setting in petripots. Hundred grams of soil mixture taken in each petripot and distilled water was added till saturation and allowed to settle and allowed to dry. After 3 days of setting the soil mixture again was mixed thoroughly and allowed to dry. To this mixture, measured amount of air dried, powdered solid waste of the Chlor-alkali industry was mixed thoroughly and water was added till saturation and allowed to set for 48hours. After soil toxicant setting, the toxicant mixture was allowed to air dry. After drying, the soil toxicant, the concentration / dose of the toxicant was selected from toxicity testing. Healthy seeds were selected and ten seeds were planted in each petripot and care was taken to see that all the seeds were inside the soil mixture. Water was added till saturation and the wet Petri pots were kept in the culture room and normal Photo Inductive Cycles and normal temperature was provided in culture racks. Seed germination and seedling establishment was noted at 24hour interval. From each replicate 10 seedlings were selected randomly and shoot and root lengths were measured, with the help of a scale. Ten seedlings from each replicate were taken, the shoots were separated from the roots and washed thoroughly with distilled water, surface dried by means of blotting paper. Then fresh weights of roots and shoots were taken separately by a single pan electric balance (Dhona make). The weighed shoots and roots were kept in an oven for 48 hours at a temperature of 80^{0}C and their dry weights were recorded at 24 h of interval till we get a constant weight of the samples. Moisture content loss of the shoot and root was calculated from weight measurements. Shoot / Root fresh weight and dry weight ratio values were calculated from the values obtained during the experiment. From the data of germination studies, four concentrations were selected. Future experiments were conducted at LC_{00} (MAC value - Maximum Allowable Concentration), LC_{10}, LC_{50} and LC_{90} values, to find out the effects of the solid waste extract on the growth performance of a crop plant. Percent of seed germination was counted visually by counting the number of seeds germinated. The root and shoot length was measured by a centimeter scale. The fresh and dry weight of the seedlings was measured in a single pan balance. The amount of total chlorophyll and total pheophytin was estimated optical density method by UV-Visible Spectrophotometer and calculated by using the formula given by Vernon (1960). All the obtained values were statistically analyzed.

Results

Table-1: Physico-chemical analysis of solid waste collected from the solid waste dumping site: (Values are mean of five samples ± standard deviation)

Sl. No.	**Physical properties**	**Solid waste**
1	Texture	Clay
2	Temperature	$26^{o}\pm2^{o}C$
3	Colour	Grayish white
4	Specific gravity	2.6
5	Water holding capacity	37% by volume
6	Air content	24% by volume
Sl. No	**Chemical properties**	**Solid waste**
1	pH	8.6±0.4
2	Phosphate	51.08±7.6 mg Kg^{-1} dry wt
3	Chloride	648.4±13.4 mg Kg^{-1} dry wt
4	Calcium	139.24±8.8 mg Kg^{-1} dry wt
5	Magnesium	28.26±6.4 mg Kg^{-1} dry wt
6	Sodium	151.4±14.6 mg Kg^{-1} dry wt
7	Potassium	42.7±8.5mg Kg^{-1} dry wt
8	Total nitrogen	18.4±2.6 mg Kg^{-1} dry weight
9	Mercury	104.3±16.5 mg Kg^{-1} dry wt.

The analyses indicated the toxic nature of the solid waste. Significant amount of mercury was recorded in the solid waste of the Chlor-alkali industry. The solid waste of the Chlor-alkali industry contained a significant amount of mercury. The solid waste was collected from different dumping sites and residual mercury was estimated. The mercury concentration ranged from 85.5±8.3 mg Kg^{-1} dry wt to 119.8±14.7 mg Kg^{-1} dry wt. The collected samples were mixed, dried, powdered and used for the experiments. The solid waste powder prepared in the laboratory contained 104.3±16.5 mg of mercury Kg^{-1} dry wt. Interesting results were obtained. The control set showed 100% seed germination. In case of solid waste treatment the percent germination decreased to 72% after 144hrs of germination (Fig.1). Insignificant increase in germination was observed in case of *Azadirachta* leaf (78%) and *Oscimum* leaf (84%) extracts application. Little increment was noted. However, when *Jatropha* leaf (35%) and *Calotropis* leaf (28%) extract was applied further depletion in germination was observed. (Fig.1), this indicated that the application of both *Jatropha* and *Calotropis* leaf extracts in solid waste exposed crop fields will not help for reclamation of contaminated soil. The seedling establishment data supported the germination data and showed a similar trend indicating possible use of *Azadirachta* leaf and *Oscimum* leaf extracts for reclamation of mercury contaminated crop fields. Both leaf extracts can reduce the toxicity of mercury acting as a masking agent and the extracts can act as biofungicide.

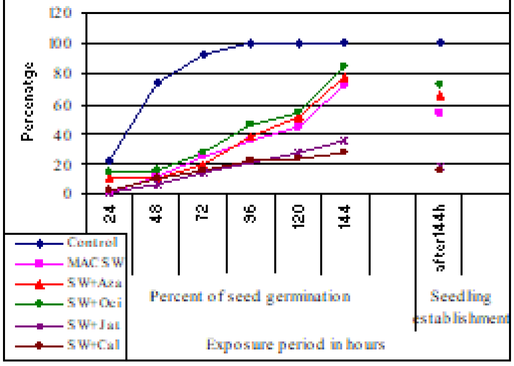

Fig.1.Percent of seed germination and seedling establishment in different exposure periods in pot culture.

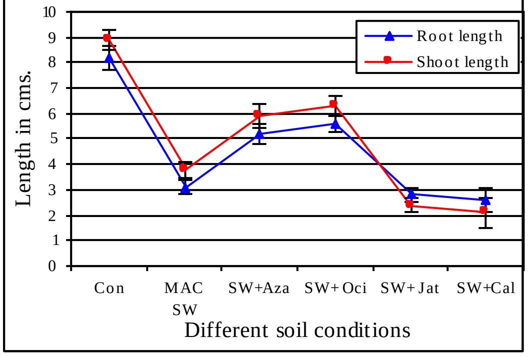

Fig. 2. Changes in root and shoot length of the control and exposed seedlings exposed to differentplant leaf extracts.

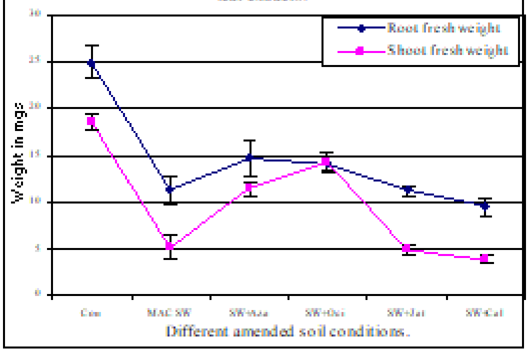

Fig.3. Changes in root and shoot fresh weight in control and exposed seedlings exposed to different waste and leaf extracts.

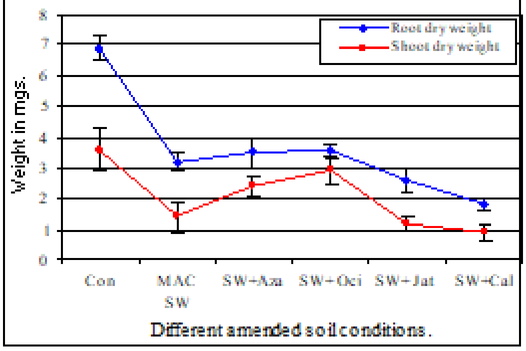

Fig. 4. Changes in root and shoot dry weight in control and exposed seedlings exposed to different plant leaf extracts.

Fig.2 showed the changes in root and shoot length in control and solid waste exposed seedlings after 144hrs of germination. The root length decreased from 8.2±0.4cm to 3.1±0.3cm incase solid waste exposure; increased in *Azadirachta* leaf (5.2±0.5cm) and *Oscimum* leaf (5.6±0.4cm) extracts application further decreased to 2.8±0.3cm in *Jatropha* and 2.6±0.2cms in *Calotropis* leaf extracts application.The shoot length decreased from 8.9±0.4cm to 3.8±0.3cm incase solid waste exposure; increased in *Azadirachta* leaf (5.9±0.5cm) and *Oscimum* leaf (6.3±0.3cm) extracts application further decreased to 2.4±0.3cm in *Jatropha* and 2.1±0.6cms in *Calotropis* leaf extracts application (Fig.2). The root fresh weight decreased from 24.9±1.8mg to 11.2±1.5mg incase solid waste exposure; increased in *Azadirachta* leaf (14.6±1.9mg) and *Oscimum* leaf (14.1±0.8mg) extracts application further decreased to 11.2±0.6mg in *Jatropha* and 9.5±0.9mg in *Calotropis* leaf extracts application. The shoot fresh weight decreased from 18.5±0.9mg to 5.2±1.4mg incase solid waste exposure; increased in *Azadirachta* leaf (11.4±0.7mg) and *Oscimum* leaf (14.2±1.1mg) extracts application further decreased to 4.8±0.5mg in *Jatropha* and 3.8±0.4mg in *Calotropis* leaf extracts application (Fig.3).The root dry weight decreased from 6.9±0.4mg to 3.2±0.3mg incase solid waste exposure; increased in *Azadirachta* leaf (3.5±0.5mg) and *Oscimum* leaf (3.6±0.2mg) extracts application further decreased to 2.6±0.4mg in *Jatropha* and 1.8±0.2mg in *Calotropis* leaf extracts application. The shoot dry weight decreased from 3.6±0.7mg to 1.4±0.4mg incase solid waste exposure; increased in *Azadirachta* leaf (2.4±0.3mg) and *Oscimum* leaf (2.9±0.4mg) extracts application further decreased to 1.2±0.2mg in *Jatropha* and 0.9±0.3mg in *Calotropis* leaf extracts application (Fig.4).

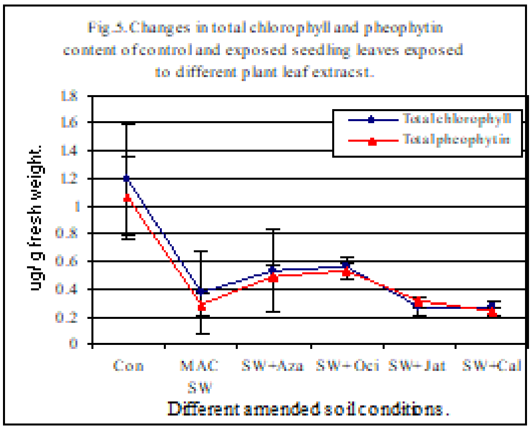

Fig.5. Changes in total chlorophyll and pheophytin content of control and exposed seedling leaves exposed to different plant leaf extracst.

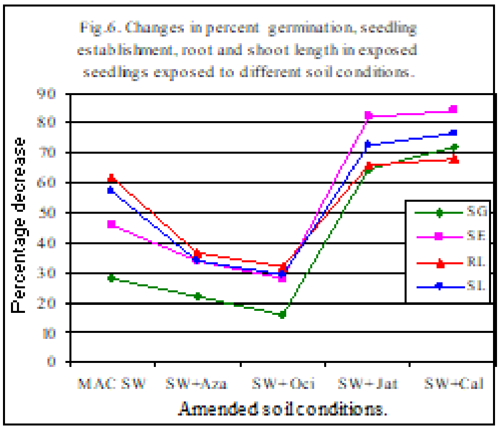

Fig.6. Changes in percent germination, seedling establishment, root and shoot length in exposed seedlings exposed to different soil conditions.

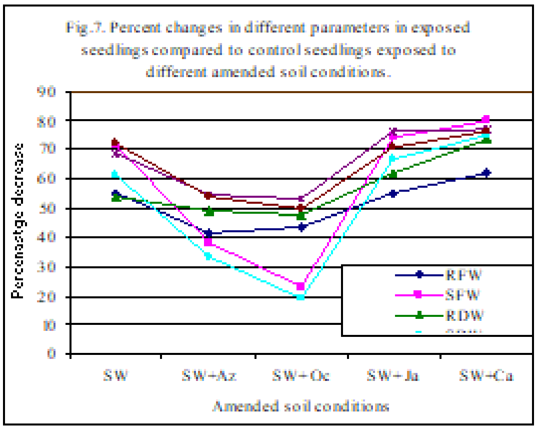

Fig.7. Percent changes in different parameters in exposed seedlings compared to control seedlings exposed to different amended soil conditions.

The total chlorophyll content decreased from 1.19±0.4mg g^{-1}dry weight to 0.37±0.3mg g^{-1}dry weight in case solid waste exposure; increased in *Azadirachta* leaf (0.54±0.3mg g^{-1}dry weight) and *Oscimum* leaf (5.6±0.08mg g^{-1}dry weight) extracts application further decreased to 0.28±0.06mg g^{-1}dry weight in *Jatropha* and 0.27±0.05mg g^{-1}dry weight in *Calotropis* leaf extracts application. The total pheophytin content decreased from 0.06±0.3mg g^{-1}dry weight to 0.29±0.08mg g^{-1}dry weight incase solid waste exposure; increased in *Azadirachta* leaf (0.49±0.09mg g^{-1}dry weight) and *Oscimum* leaf (0.53±0.06mg g^{-1}dry weight) extracts application further decreased to 0.31±0.04mg g^{-1}dry weight in *Jatropha* and 0.25±0.03mg g^{-1}dry weight in *Calotropis* leaf extracts application (Fig.5). Significant decrease in germination was observed. Seedling establishment gave a clear picture where *Azadirachta* leaf (34%decrease) and *Oscimum* leaf (28%decrease) extracts application further decreased to 82%decrease in *Jatropha* and 84%decrease in *Calotropis* leaf extracts application was noted (Fig.6). The root length showed a similar trend. In case of SW exposure, 62.2% decrease, in case *Azadirachta* leaf application 36.6% decrease, in case *Oscimum* leaf application 31.7% decrease, in case *Jatropha* leaf application 65.9% decrease, in case of *Calotropis* 68.3% decrease in root length was observed. The shoot length changes showed a similar trend like root length changes. In case of SW exposure, 57.3% decrease, in case *Azadirachta* leaf application 33.7% decrease, in case *Oscimum* leaf application 29.2% decrease, in case *Jatropha* leaf application 73% decrease, in case of *Calotropis* 76.4% decrease in shoot length was observed (Fig.6).The root fresh weight showed a similar trend. In case of SW exposure, 55% decrease, in case *Azadirachta* leaf application 41.4% decrease, in case *Oscimum* leaf application 43.4% decrease, in case *Jatropha* leaf application 55% decrease, in case of *Calotropis* 61.9% decrease in root fresh weight was observed. The shoot fresh weight changes showed a similar trend like root fresh weight changes. In case of SW exposure, 71.9% decrease, in case *Azadirachta* leaf application 38.4% decrease, in case *Oscimum* leaf application 23.2% decrease, in case *Jatropha* leaf application 74.1% decrease, in case of *Calotropis* 79.5% decrease in shoot fresh weight was observed (Fig.7). The root dry weight showed a similar trend. In case of SW exposure, 53.6% decrease, in case *Azadirachta* leaf application 49.3% decrease, in case *Oscimum* leaf application 47.8% decrease, in case *Jatropha* leaf application 62.3% decrease, in case of *Calotropis* 73.9% decrease in root dry weight was observed. The shoot dry weight changes showed a similar trend like root fresh weight changes. In case of SW exposure, 61.1% decrease, in case *Azadirachta* leaf application 33.3% decrease, in case *Oscimum* leaf application 19.4% decrease, in case *Jatropha* leaf application 66.6% decrease, in case of *Calotropis* 75% decrease in shoot dry weight was observed (Fig.7). The total chlorophyll content decreased in all exposure cases showing a similar trend. In case of SW exposure, 68.9% decrease, in case *Azadirachta* leaf application 54.6% decrease, in case *Oscimum* leaf application 52.9% decrease, in case *Jatropha* leaf application 76.5% decrease, in case of *Calotropis* 77.3% decrease in total chlorophyll content was observed. The total pheophytin content also decreased like total chlorophyll changes and the trend was similar. In case of SW exposure, 72.6% decrease, in case *Azadirachta* leaf application 53.8% decrease, in case *Oscimum* leaf application 50% decrease, in case *Jatropha* leaf application 70.8% decrease, in case of *Calotropis* 76.4% decrease in total pheophytin content was observed (Fig.7). All the observed data indicated that reclamation of solid waste contaminated soil can be done by the use of *Oscimum* leaf extract. *Azadirachta* leaf extract showed better result over *Jatropha* and *Calotropis* leaf extract. *Azadirachta* leaf extract can be used as fungicide and also it supports reclamation of the contaminated crop fields. This study indicated that both *Jatropha* leaf and *Calotropis* leaf extract application does not support reclamation rather further depletion in parameters were noted and these applications should be avoided.

Discussion

The solid waste of the Chlor-alkali industry contained significant amount of mercury which impacts the environment, flora and fauna. The industry discharges its wastes in to the environment without any physico-chemical and biological treatment except pH management. Presence of metallic mercury in effluent canal and solid waste dump sites was observed by the workers of our laboratory. The reports that the decrease in crop production in the surrounding area was due to mercury contained river water, which was used by the farmers for irrigation. Mohammed *et al*., (2019) reported that heavy metal pollution of Egyptian water was primarily because of agricultural and industrial wastes and fish was the main sufferer in water bodies. Cuciureanu *et al*., (2020) reported that red mud was the main waste produced during alkaline leaching of bauxite ore and a large quantity of waste was generated in the process and were discharged on large areas year by year needs attention. As these wastes can cause serious environmental and health issues, the author tried to reuse or recycle the red mud wastes for a green future. Patel and Pal (2015) reported that the studied red mud waste was strongly alkaline ranging between 10 to 13 and warned that these wastes were corrosive in nature can cause alarming environmental problems. Cui *et al*., (2019) reported the leaching behavior of metal elements of red mud was controlled by solubility and not by the concentrations of these metal elements in the red mud waste. This idea can be used while studying the impact of red mud waste on any aquatic animal or plant, as these elements can only be absorbed from the waste, if they are available in the soluble form. Sun *et al*., (2019) studied the geochemical characteristics and presence of toxic elements in alumina refining waste and lechate coming from management facilities and reported the presence of minor elements and trace elements in the waste and these wastes can be toxic to aquatic life due to hyper alkaline nature of red mud lechate. Zhou *et al*., (2018) reported selective leaching of scandium from red mud and opined that selective leaching is important for reclamation and solid waste treatment while working on red mud waste reclamation. Sarath Chandra and Krishnaiah (2018) conducted a detailed geotechnical analysis of red mud and reported that the waste is iron-oxide rich and commented that the storage and disposal of red mud is the biggest problem and this red mud waste seriously contaminates the aquatic ecosystems. Patnaik *et al* (2023) reported the impact of red mud waste on the surrounding crop fields and water bodies. The surrounding areas near industrial establishments may show higher levels of metals via aerial deposition in particulate form. Commercial plastics use variety of heavy metals in their formulations (Wagner *et al.*, 1992). Metallic cations are highly essential for many enzymes to achieve their catalytic activity. These cations maintain the acid base balance; and are also highly essential for the ionic composition of the body fluids. Disturbance in electrolyte concentration are quite common in toxicity. Different studies on electrolyte change resulting from toxic status have produced a variety of diverse effects, because of differential size of toxic actions in the body. Many environmental pollutants released into the atmosphere eventually settled and reach the soil by direct precipitation or deposition on vegetation and consequently as washings by rain water from vegetation to soil. The deposited chemicals on plant leaves if eaten by grazers enter into animal body and pass through the food chain. The enrichment of these toxic metals into the biosphere started with industrial pollution (Nriagu, 1970) and these metal accumulations in land and water bodies now posse's significant environmental and human health problems. Radha and Panigrahi (1998) reported that the solid waste of the Chlor-alkali industry showed drastic impact on the seed biology of exposed rice seedlings indicating impact of mercury. Heavy metals are potent carcinogens. Some of heavy metals (Fe, Cu and Zn) are essential for plants and animals (Wintz *et al*., 2002). The availability of heavy metals varies in different medium of the environment. Some of these heavy metals such as Cu, In, Fe, Mn, Mo, Ni and Co are called micronutrients (Reeves and Baker, 2000), and are only toxic when taken in excess of requirement (Monni *et al*., 2000; Blaylock and Huang, 2000). Like all organisms, plants are often in a state of dilemma that some heavy metal ions are essential micronutrient, while the same at higher concentrations and even more ions such as Cadmium, Mercury, Arsenic, etc are strongly poisonous to the metabolic activities. Researches have been conducted throughout the world to determine the effects of toxic heavy metals on plants (Reeves and Baker, 2000; Fernandez and Henariques, 1991). Several heavy metal ions are reported to cause preoccupation of membrane lipids (plasma and chloroplast membrane). For example Cd modified the lipid composition of root plasma membrane of *Pisum sativum* (Hernandez and Cooke, 1997).Sahu & Panigrahi (2002) reported that the effluent and solid waste coming out from the chlor-alkali industry is deadly toxic. Shaw *et al*, (1986) reported that the effluent of the industry is toxic all biosystems living in the contaminated sites. Among metals, increased level of lipid peroxidation has been reported under Cd stress in *Oryza sativa* (Ros *et al*., 1990; Shah *et al*., 2000), *Holcus lanatus* (Hendry *et al*., 1992) and *Phaseolus vulgaris* (Somasekharaiah *et al*., 1992; Chaoui *et al*., 1997). Increased lipid peroxidation is also reported under Ni stress in *Oryza sativa* (Ros et al., 1990), Al stress in *Glycine max* (Cakmak and Horst, 1991) and tobacco (Yamamoto *et al.*, 1997), In stress in *Phaseolus vulgaris* (Chaoui et al., 1997; Weckex and Clijsters, 1997) and rice (Panda and Khan, 2003), Cu stress in *Silene cucubalus* (DeVos *et al*., 1991, 1993) and *Lycopersicum esculentum* (Mazhoudi *et al*., 1997), Pb stress in *Oryza sativa* (Verma and Dubey, 2003), and Cr stress in rice and wheat (Panda and Khan, 2003). Studies on heavy metal tolerance in plants indicate that root growth is particularly sensitive to heavy metals (Punz and Sieghardt, 1993). Copper and Cadmium in combination have affected adversely the germination, seedling length, and number of lateral roots in *Solanum melongena* (Neelima and Reddy, 2002). Reduction in root growth due to heavy metals has also been reported in wheat seedlings (Oncel *et al*., 2000). The number of leaves and branches, root and shoot length and biomass decreased as concentration of Cr increased in egg plant and tomato (Purohit *et al*., 2003) and in barley (Aery and Rana, 2003). The dry matter and yield of many higher plants such as pea, wheat, rape seed and maize have been reported to decrease under multiple heavy metal stress. Presence of Zn at higher concentrations retarded the growth and development of plants by interfering with certain important metabolic processes (Alia *et al*., 1995). It was observed that the solid waste contained significant amount of mercury much more than prescribed limit. The lechate and washings from the solid waste dumping site enter into the river during rainy season increasing the mercury level in the river water. This river water was used to irrigate the crop fields at down stream which contaminated the crop fields. The solid waste analysis indicated the highly toxic nature of the waste containing significant amount of mercury. The seed germination and seedling establishment decreased significantly in the solid waste exposed pots with the increase in solid waste (containing mercury) concentration, when compared to the respective control values. The pigments like total chlorophyll and total pheophytin content significantly decreased in exposed seedling leaves compared to control seedling leaves of the crop seedlings. Four plants were selected based on their economic importance. The leaf extracts were used for the experiments to find out a possible solution for reclamation of the solid waste. In the experimental pots, along with solid waste, 10ml of the plant extract was applied for consecutive 5days in each petripot. It was observed that the phytochemicals extracted from both *Calotropis* and *Jatropha* could not support reclamation rather further deterioration was observed. But in case of *Azadirachta* and *Oscimum* leaf extract 100% recovery was not observed. The observed values were much less than the control value. No significant improvement in seed germination or seedling growth was noted in solid waste exposed pots. However, we can conclude that application of both *Azadirachta* and *Oscimum* can support crop improvement. As *Azadirachta* leaf can be used as biopesticide instead of synthetic chemical application. All the observed data indicated that reclamation of solid waste contaminated soil can be done by the use of *Oscimum* leaf extract. *Azadirachta* leaf extract showed better result over *Jatropha* and *Calotropis* leaf extract. *Azadirachta* leaf extract can be used as fungicide and also it supports reclamation of the contaminated crop fields. This study indicated that both *Jatropha* leaf and *Calotropis* leaf extract application does not support reclamation rather further depletion in parameters were noted and these applications should be avoided. The leaf extracts negates the impact of solid waste insignificantly but can be considered as a viable option for reclamation studies. Mercury contained in the solid waste is highly toxic and should not be released prior to biological treatment into the environment as the toxicant severely affects the environment and the crop plants.

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