Direct Research Journal of Public Health and Environmental Technology
Vol. 8(6), Pp. 80-91, July 2023
ISSN 2734-2182
DOI: https://doi.org/10.26765/DRJPHET7621097354
Article Number: DRJPHET7621097354

https://directresearchpublisher.org/drjphet/

Original research

Water Pollution Control using Water Hyacinth Treated with Sodium Azide Mutagen: A Viable Tool for Phytoremediation

Jim Jonathan Eze*, Umar, I.D., and Solomon, R. J.

Department of Biological Sciences, Faculty of Sciences, University of Abuja, Nigeria.
Corresponding author email:jim_4jesus@yahoo.com

Received 2 June 2023; Accepted 28 June 2023; Published 12 July 2023

ABSTRACT: This study assessed the phytoremediation of aquatic habitats contaminated with crude oil in University of Abuja. These habitats were simulated in twelve (12) white containers in the Biological Garden of the Department of Biological Sciences. Some of the water hyacinth plants used in this research were treated with sodium azide, a chemical mutagen to induce beneficial mutation in the genes of the plants that can result in an improvement in the rate of phytoremediation by the plant. The result from this study showed a significant decline in BOD, DO, TDS, EC and pH through the weeks of the studies for each month both for the plants that were genetically modified using sodium azide and those that were not genetically modified. The survival rate of the genetically modified water hyacinth was also higher, almost one hundred percent in some cases compared to the ones that were not genetically modified. The genetically modified plants identified as C, C_1, C_2 and D, D_1 and D_2 also gave a better result in terms of uptake of heavy metals like FE^{2+}, PB^{2+} and SO_2^{+4} ions. The study recommends that phytoremediation by plants can be improved upon using chemical mutagens like sodium azide that can induce beneficial mutation which will bring about an improvement of the plants natural ability to clean-up contaminated habitats through phytoremediation.

Keywords: Water pollution control, Water Hyacinth, sodium azide, phytoremediation

Citation: Eze, J. J., Umar, I.D., and. Solomon, R. J. (2023). Water Pollution Control Using Water Hyacinth Treated with Sodium Azide Mutagen: A Viable Tool for Phytoremediation. Direct Res. J. Public Health and Environ. Technol. Vol. 8(6), Pp. xxx-xxx https://doi.org/10.26765/DRJBB1716310427. This article is published under the terms of the Creative Commons Attribution License 4.0.

INTRODUCTION

All over the world, efforts are being made to remediate or recover degraded or polluted lands and water bodies that have been contaminated via crude oil spillage as well as other forms of pollutants (Bekeowei and Ohwo, 2021). Depending on biogeochemical processes, many organic pollutants like crude oil are involved in adsorption, desorption and transformation processes and can be made available to benthic organisms as well as organisms in the water column through the sediment-water interface (Perelo, 2010). Plants have been found to be very efficacious in degrading these pollutants and in remediating such contaminated environments. In recent years, phytoremediation, which is defined as the use of green plants to reduce organic and inorganic environmental pollutants (Hejna *et al.*, 2020; Mahalakshmi *et al*. 2019a; Cunningham and Ow, 1996; Yadav *et al*., 2018), come to be regarded as a cheap and environmentally-friendly alternative treatment technology (Singh and Balomajumder, 2021). Aquatic plant-based cost-effective treatment technologies can be used for wastewater in third world countries like Africa where there is a serious environmental threat posed by pollution, especially crude oil pollution as experienced in the Niger-Delta region of Nigeria. It has many advantages in compared to the other treatment methods (Shi *et al.*, 2020; Abbas *et al*., 2019; Daud *et al*., 2018; Gerhardt, 2017; Leguizamo *et al*., 2017; Rezania *et al*., 2015; Pilon-Smits, 2005; Yadav *et al*., 2018). To make phytoremediation an ecofriendly technology, plants should have characteristics such as quick growth rate, high biomass yield, the uptake of a large amount of pollutants, the capacity to transport pollutants in above ground parts of plant, and a mechanism to tolerate pollutants toxicity (Ali *et al*., 2013; Arslan *et al*., 2017; Burges *et al*., 2018; Rezania *et al*., 2015b). Other factors such as pH, availability of nutrient and salinity have a very great effect on the phytoremediation potential and plant growth (Rezania *et al*., 2015c; Reeves *et al*., 2018 and Tewes *et al*., 2018; Yadav *et al*., 2018). Pollutants bind to specific points on the surface of the root. Phytoremediation is further enhanced by the accumulation of pollutants in the roots and the transfer to other parts of plant (Burges *et al*., 2018). Water hyacinth (Eichhornia crassipes) is preferred among several plants for phytoremediation because of its capability to grow in highly polluted water (Mahalakshmi et al., 2019; Saha et al., 2017; Ebel *et al*., 2007; Roy and Hanninen, 1994). Water hyacinth can have significant variation in nutrients, pH levels (optimum growth at 6 - 8 pH) and temperatures (from 1 to 40 °C, optimum growth at 25–30 °C) (Hounkpe *et al*., 2022). This technology has become more popular as there has been more interest in recent times in conservation of the ecosystem, especially with the recent Global Cimate Action that was presented at the 26th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26) in Glasgow, United Kingdom (www.uk.cop26.org). World leaders committed themselves to the huge and urgent task of saving the planet by tackling the great menace of climate change which poses a great threat to the survival of our planet and every biodiversity represented in it (www.uk.cop26.org). Curbing the menace of pollution is very vital to this task and phytoremediation remains the most viable option to salvaging our polluted habitats (Yan et al., 2020).

Globally speaking the problem of oil spillage remains a problem that is yet to be solved. Many nations of the world especially oil producing nations like Nigeria have continued to be puzzled by the menace of oil spillage. In Nigeria there has been incessant oil spill within the oil fields in the Niger-Delta region from old pipelines and illegal oil bunkering. According to UNEP report (2011), there are 116 oil wells, 5 flow stations, 12 manifolds and over 122km of pipeline rights of way. It has been reported that a family was burnt to death because they were fetching refined products instead of water from a well dug inside their compound that is about 10 meters from a refined product pipeline (www.thecable.ng/ogoni-cleanup). There is therefore a need for oil companies and local communities to partner or collaborate with research experts to map out the entire network of oil facilities and carry out a n assessment of areas prone to corrosion and leakage and find a way to stop it (Abraham and Ekpensi, 2017). As a result of the menace of oil spillage in the Niger-Delta, water is polluted leaving the people with unclean and contaminated water for drinking and domestic purposes (Abraham and Ekpensi, 2017). The biodiversities living in water or land in such areas affected by oil spillage are destroyed even as some species have gone into extinction as a result of the scourge caused by oil spillage (Abraham and Ekpensi, 2017). The oil cannot be cleaned easily except by the use of conventional methods like chemical dispersants so it creates another complex problem for future generations. These chemicals are toxic to aquatic and terrestrial life. The most prominent chemicals used by Exxon and the United States Environmental Protection Agency for the Exxon Valdez cleanup, though judged to be successful to a certain degree, were controversial due to effects on the environment and public health (www.history.com/amp/Exxon-valdez laid to rest). According to Material and Safety Data Sheet (MSDS) for EAP22, skin contact and inhalation are the primary routes of occupation exposure; it can be moderately toxic if absorbed through the skin and eyes (Abraham and Ekpensi, 2017). High vapor concentrations may initiate the eyes and respiratory tract and may result in Central Nervous System (CNS) effects including headaches, dizziness, nausea and drowsiness. Also, prolonged or repeated contact may remove natural oils from the skin, dry the skin, and cause irritation, redness, and rash (Abraham and Ekpensi, 2017).

Methods for phytoremediation of contaminated lands and water bodies such as lakes, rivers, seas, etc. have been described in many researches (Salt *et al*., 1998). Plants such as water hyacinths (*Eichornia crassipes*), onion (*Alium cepa*), Poplar trees (*Populus spp.*), American pondweed (*Potamogeton nodosus*), Forage Kochia (*Kochia spp.*), Alfalfa (*Medicago sativa*), etc. have been used in phytoremediation practices, etc. (Fresh Water Management Series No. 2, 2 000). Algae has been extensively used in recent times to carryout phytoremediation and has proved to be effective in hyperaccumulation of heavy metals as well as degradation of xenobiotics (Suresh and Ravishankar, 2004). Worldwide trees, grasses, herbs, algae as well as other microorganisms such as phytoplanktons are being used increasingly for cleaning polluted sites.

The most important point to consider in implementing phytoremediation is the selection of the right plant (Roongtanakiat *et al*., 2007; De Stefani *et al*., 2011) which should have a high uptake of organic and inorganic pollutants, grow well in polluted water and be easily controlled in quantitatively propagated dispersion (Roongtanakiat *et al*., 2007). Technics in genetics can be used to improve the phytoremedial property of plants. Chemical mutagens like sodium azide can be used to cause beneficial mutation in plants such as the ability to accumulate and degrade harmful pollutants especially crude oil (Das and Chandran, 2011; Subashandrabose *et al.,* 2013).

Phytoremediation can be done insitu that is directly on the site of contamination and exsitu by moving the contaminated material to a controlled environment where the technic of phytoremediation can be easily applied (Khan et al., 2020).

Phytoremediation is on the brink of commercialization (Watanabe, 1997) and is given a rapidly increasing market potential (Flathman and Lanza, 1998). The phytoremediation market is still emerging in Europe, while in the US revenues had exceeded $300 million in 2007 (Campos *et al*., 2008). The advantage of phytoremediation compared to other conventional methods of remediating the environment are: it is more cost effective; it is more environmentally friendly, it is more aesthetically pleasing than conventional methods such as the use of chemical dispersants; its potential benefits are very high and extremely attractive to scientists and business men; it enables scientists to reclaim and recycle usable materials including a wide variety of precious metals from soil (Abdulla, 2002; Huang and Cunningham, 1996). Phytoremediation is economical because only solar energy must be present to maintain the system. The greatest advantage of this technology is that it utilizes the inherent agronomic benefits of plants (Kirchner, 2002).This study was conducted to determine the use of Water Hyacinth Mutagen with sodium azide as tool for phytoremediation of aquatic habitats contaminated with crude oil in University of Abuja.

Literature review on water hyacinth

Water hyacinth and its use in phytoremediation

Water hyacinth is a perennial fresh water plant that is free-floating or rooted in some cases (Moyo *et al*., 2013). It belongs to the family, Pontederiaceae that has proven to be a significant economic and ecological burden to many sub-tropical and tropical regions of the world (Mapira, 2011). Water hyacinth is listed as one of the most important productive plants on earth that shows logistic growth like other floating plants (Moyo *et al*., 2013). It is known to be an invasive plant across the world which acts as a nuisance weed which invades rivers, lakes and dams that have been polluted (Nazir *et al*., 2011). The IUCN lists it as the most dangerous invasive species. It has invaded freshwater bodies in over 50 countries on five different continents and is present in Southeast Asia, Southeastern United States, Central and Western Africa, and Central America (Lu *et al*., 2007; Martinez and Gomez, 2007). Water hyacinth has a very fast reproduction rate and can easily cover the surface of water bodies, forming a thick “carpet”.

As a result of its very fast growth rate, ability to compete effectively with other aquatic plants and its ease of propagation, water hyacinth has been known to negatively impact the water bodies where it is found (Moyo *et al*., 2013). This results in an explosive growth of water hyacinth in the aquatic habitat which interferes with the use and management of water resources. Some common problems associated with its growth in aquatic habitats are; interference with navigation, water flow, the recreational use of aquatic systems, hydroelectric power risk it poses through mechanical damage, change in the plant and animal communities of fresh water habitats, acts as an agent of the spread of diseases (Moyo *et al*., 2013). It also brings about a decline in the level of physico-chemical characteristics of water such as temperature, pH, biological oxygen demand (BOD), dissolved oxygen, nutrient levels, etc (Moyo *et al*., 2013).

Water hyacinth has been found to also have some positive impacts. It is a plant of great ornamental importance in gardening because of the beauty of its foliage and flowers. It is also used in remediating or cleaning up polluted water in aqauatic habitats. This is known as “Phytoremediation”. It has been found to be effective in remediating water bodies that are polluted with metals, sewage wastes, crude oil and other toxins which harm the aquatic biodiversity (Hammad, 2011). Studies have shown that vegetated portions of a lake covered with water hyacinth had significantly lower concentrations of phosphates and ammonium compared to unvegetated regions. This result was attributed to the ability of water hyacinth to use these nutrients and was estimated to have a daily removal capacity of 1.5% ammonium load of the lake (Moyo *et al*., 2013).

The economic potential of Water Hyacinth as a viable tool for phytoremediation

The successful use of phytoremediation for remediating contaminated or polluted habitats is dependent on several factors. This includes; high biomass production ability of the plant and the plant’s responsiveness to agricultural practices that make for easy planting and harvesting, easy harvesting or disposability, plants natural uptake ability, binding of contaminants to root tissue either chemically or physically, transport of the contaminant from root to shoot and speed of growth are among some of the very important factors (Pas-Alberto *et al*., 2013). Water hyacinth is a typical plant for phytoremediation, especially in aquatic habitats because it meets almost all of the criteria for phytomediation. Many studies report that water hyacinth is very effective in removing organic wastes from polluted water bodies (Shahabaldin *et al*., 2015).

Water hyacinth has been found to be very efficient in removal of pollutants from contaminated water (Shahabaldin *et al*., 2015). It forms the central unit of a recycling engine driven by photosynthesis and therefore the process is sustainable, energy efficient and cost efficient under a wide variety of rural and urban conditions (Swain and Mohanty, 2014). It can be established and survived in wastewater (Sooknah and Wilkie, 2004). The enormous biomass production rate, its high tolerance to pollution, and its heavy metal and nutrient absorption capacities (Singhal and Rai, 2003; Ingole and Bhole, 2003; Liao and Chang, 2004; Jayaweera and Kasturiarachchi, 2004; Swarnalatha *et al.*, 2015) qualify it for use in wastewater treatment ponds. For example, studies have shown that about 1 million L/ day of domestic sewage could be treated over an area of 1 ha through water hyacinths, reducing the biological oxygen demand (BOD) and chemical oxygen demand (COD) by 89% and 71%, respectively (Zayed and Terry 2003; Mohanty *et al.* 2005a, 2009, 2010).

Inducing beneficial mutation using sodium azide in plants

Sodium azide is relatively safe to handle, inexpensive and non-carcinogenic as compared to other mutagens (Eze and Dambo, 2015). It has been reported to be the least dangerous and the most efficient mutagen which is mutagenic in several crop species (Adamu and Aliyu, 2007; Mostafa, 2011). It is an ionic compound and it's mutagenicity is mediated through an organic metabolite (analogous to L. azidoalanine) of the azide compound generated by acetylserine sulfhydrylase enzyme (Grutzka *et al.*, 2012). This metabolite enters the nucleus of the cell and interacts with the plants DNA, creating point mutations in the plant genome. The mutagenic effect of sodium azide depends on the pH of the solution and can be increased when germinated seeds are treated (Grutzka *et al.*, 2012). It has been found to have potential in tissue culture mutagenesis for inducing biochemical mutants because it is a point mutagen and is known to be highly mutagenic in mammals (Eze and Dambo, 2015). Being a strong mutagen in plant, it affects the different parts of the plants and their growth developmental phenomena by disturbing the metabolic activities. Treatments with sodium azide resulted in increased rate of maturity in soyabean plant (Glycene max) when higher doses were administered (Archarya *et al.*, 2004). Kiruki *et al.*, (2006) observed that mutant maize plants became resistant to *Striga hermonthica* and *Striga asiastica.* Mensah and Obadomi (2007) have also reported that barley plants became resistant to mildew disease. Sodium azide has also been shown to significantly influence the growth of and germination of wheat plant (Srivastava *et al.*, 2011).

Water pollution

Water is one of the most important natural resources, necessary for the survival of all life forms. This water resource is being polluted by several anthropogenic actions such as rapid growth of urbanization, industrialization and populations that finally make the environment polluted (Singh and Balomajumder, 2021). Phenol and cyanide pollution signifies an important environmental problem due to toxic effects of pollutants, their resistance and subsequent determination (Busca *et al.*, 2008). Until recently water pollution has been a relatively local problem of the developed world. Eutrophication is the most common problem, where inland waters and rivers are polluted with nitrogen and phosphorus run-off from fertilizers used in intensive agriculture and discharge of phosphate rich sewage effluents (Plates 1, 2 and 3). Such problems are increasingly occurring on all worldwide bases and now affect marine as well as freshwater ecosystems (Taylor *et al.*, 2005 and Mason, 1981). Sewage from coastal settlements discharges, sometimes untreated into coastal waters where it generates a direct health hazard for recreational bathers as well as marine organisms. Land drainage from urban areas, industrial and waste disposal sites is often contaminated with heavy metals or hydrocarbons. Biological concentration of heavy metals in marine food chains may give lethal doses, as occurred following the industrial discharge of mercury into coastal waters at Minamata in Japan. Here, concentrations in fish led to the deaths of many humans and other animal predators. At sub-lethal levels heavy metals and contaminants such as pesticides and oil derivatives may lower resistance to disease (Taylor *et al.*, 2005 and Mason, 1981). During the last decade measures to control and eventually stop toxic waste dumping and incineration at sea have been introduced by countries bordering the North Sea in an attempt to reduce pollution and damage to this ecosystem. Another major problem is caused by excessive soil erosion on the land surface. This increases the silt load of rivers and coastal waters

Plate 1: Bodo salt Lake, Ogoni Nigeria showing oil water pollution by oil Spillage (2017).

Plate 2: Bodo salt Lake showing mangrove trees and heavy water pollution by Oil Spillage (2017).

Plate 3: Bodo salt Lake in Ogoni showing water pollution by Oil Spillage (2017).

which may be beneficially enrich fisheries. However, it can also be destructive. For example, it is leading to coral reef destruction in the Australian Great Barrier Reef as a result of deforestation on the mainly and other important forms of water pollution include thermal pollution and oil pollution (Taylor *et al*., 2005).

MATERIALS AND METHODS

Study area

This study was conducted in the Biological Garden in the Department of Biological Sciences, University of Abuja, FCT, Nigeria. It lies between latitude $8^{o}58$ north of the equator and longitude $7^{o}10$ east of the Greenwich meridian. University of Abuja main campus is planned in phases over an area of 118sq km. It has an annual rainfall of 1650mm (Google earth, 2018) and an average temperature of 21°C to 26°C. The months of July, August and September has approximately 60% of the annual rainfall. There are two main seasons, namely the dry season with maximum temperature of 30 and 35, as well as $25^{o}C$ during the rainy season.

Plant collection

Water hyacinth (*Eichornia crassipes*) plants were obtained from Jabi Lake in Abuja at the commencement of the studies for each month.

Crude oil collection

Twenty (20) litters of raw crude oil was collected from Warri Refining & Petrochemicals Company limited (WRPC) in Ekpan – Warri, Delta State, Nigeria. It was used to contaminate the simulated aquatic habitats in the Biological Science Department of University of Abuja, where this research was carried out.

Experimental design

Water hyacinth (*Eichornia crassipes*) were brought from Jabi Lake and put into white transparent water containers which was used to simulate aquatic environments. Twenty litre of water was poured into each container which was further enriched by coopers solution, a hydroponic nutrient used for growing plants hydroponically. The coopers solution was prepared in the biology laboratory of the department of biological sciences monthly before the commencement of each month's studies. 200 mils of coopers solution were added to each container of water to make up a volume of 20 litres for the first month of the study in the rainy season in May. This was increased to 400 mils in the second month of June and further increased to 600 mils in July. This is repeated in the same manner from August to October. Ten plants were grown in each tank. Solution of crude oil was prepared with five different concentrations and a control. A stock solution of sodium azide was also prepared in the biology laboratory of the department. Some of the water hyacinth plants were isolated and treated with sodium azide solution for four hours. This was to induce mutation of the genes of the water hyacinth plant, so that comparism can be made between the rate of phytoremediation of the natural plants with the genetically modified plants. The concentration of the sodium azide used in treatment of the water hyacinth to induce mutation was also altered from 0.05 mol/dm^3 in May to 0.03 mol/ dm^3 in June and 0.01 mol/ dm^3 in July. This is repeated from August to October in the same order. This is to be able to determine the lethal dose of the sodium azide solution that is deletious to the survival of the water hyacinth or that can give optimal results. The set-up was divided into two sections. The first section is the section for plants that were not treated sodium azide to induce mutation. The second section is for the plants that were treated with sodium azide to induce beneficial mutation. The containers were labelled A - D. Each treatment is replicated twice. That means containers labelled “A” includes A, A_1, A_2 and D contain D_1 and D_2, plants that were not treated with sodium azide were labelled B and C with two replications each. This means containers labelled B are B, B_1 and B_2 while those labelled “C” are C, C_1 and C_2. Those labelled B and C were contaminated with crude oil together with their replications. Those labelled A and D together with their replications, were not contaminated with crude oil. All together there were 12 containers in thew set up with 6 containers contaminated with crude oil while the other six were not contaminated with crude oil. The control for this experiment were those labelled A, A_1 and A_2. The planting layout that will be used is completely randomized design.

Atomic absorption spectometry of raw crude oil

The raw crude oil used to contaminate the simulated aquatic habitat was subjected to atomic absorption spectrometry test in the Multi-User Science Research Laboratory in ABU, Zaria to determine the concentration of metallic ions present in the crude oil.

Atomic Absorption Spectometry of Harvested Leaves of Water Hyacinth

Leaves from each treatment of the experiment were harvested and taken to the CHESTCO laboratory in Kwali and subjected to atomic absorption spectrometry to determine the uptake of metals from the crude oil.

Data collection

Leaf length: The length of the leaves of each plant was measured before treatment with crude oil is done to determine the growth of the plants.

Leaf width: The width of the leaves of each plant was measured before contamination with crude oil and for each week of the month of the study to determine the growth of the plant.

Stem Length: The Stem length of the plant is measured before the contamination with crude oil and for each week during the month of the study to determine the growth of the plant.

Root Length: The root length of plant is measured before contamination with crude oil and for each week during the duration of the study to determine the growth of the plant.

Limnological State Estimation

Temperature: Mercury-in-glass thermometer will be used to determine the temperature of the water in the various crude oil contaminated aquatic habitats as well as the phytoremediated aquatic habitats.

Depth: A long rope marked at different portions will be used to measure the depth of water in the crude oil contaminated habitats as well as the phytoremediated aquatic habitats (APHA, 1992).

pH: pH of water is also determined for the crude oil contaminated habitat as well as the phytoremediated aquatic habitats using a pH scale (APHA, 1992).

Dissolved Oxygen (DO): DO is a very important parameter for the survival of fishes and other aquatic organisms. DO is estimated by Winkler‟s method (APHA, 1992).

Biochemical Oxygen Demand (BOD): This test measures the oxygen required for the biochemical degradation of organic matter. The method consists of placing a sample in a full, air-tight bottle and incubating the bottle under specified conditions for a specific period – 5 days at 20o C or 3 days at 27o C. Dissolved oxygen (D.O.) is measured before and after incubation, the difference between the two being the BOD value. A reagent blank is also carried out in the same manner (APHA, 1992).

Total Dissolved Solids (TDS): An electronic probe, which measures TDS was used. The values are expressed as mg/L of water. The probe was immersed directly in the water collected in a wide mouthed sampling bottle at the sampling site immediately after collection for a period of time sufficient to permit constant reading (APHA, 1992).

Electrical Conductivity (EC): Conductivity meter, was used to measure conductivity and expressed as m mhos or µ mhos/cm or as µS/cm (APHA, 1992).

Survival studies

At the end of each week, the number of plants that survived in each treatment is estimated and this is done twice during each month of the study. This is done using hand count.

Statistical analysis

The data collected will subjected to analysis of variance (ANOVA) to compare the means and Duncan Multiple Range Test will be used to rank the various parameters for each treatment at 5% or p =0.05 level of significance.

RESULTS AND DISCUSSION

Temperature

There is also a relationship between temperature and dissolve oxygen. The higher the temperature, the lower the dissolved oxygen, while the lower the temperature, the higher the dissolved oxygen. There was a slight temperature change observed from the month of May to July and the months of August to September with the highest temperature recorded as 27^0C in the month of October in week two, treatment D_2 while the lowest temperature was recorded as 7^0C and was recorded in the month of August in week one, treatment A_1. This is in line with the result by Rezenia *et al.*, 2015 who reported a reduction in the temperature of domestic wastewater treated with water hyacinth. The result showed that there is a relationship between temperature and water depth. It was observed that the water level decreased more with increase in temperature. This relationship is not significant. The mean value of D0 is 24.01 and the standard deviation is 9.09 (Table 1).

Table 1: Mean and standard deviation of limnology study (using repeated measures ANOVA)

Properties	EC	pH	TP	DO	DTH
MEAN	1.203	6.36	27.9	24.09	18.387
STANDARD DEVIATION	0.6145	0.716	.302	9.59	1.5595

Depth

The result of the studies showed a decline in water depth during the time of the study. The water level declined steadily from week one and continued in week two. The greatest decline of water depth or level was observed in week two in the month of May with a reading of 14L in treatment D and D_1. The decrease in water level can be due to the plants use of water for photosynthesis. We will also observe that the treatments with plants that have been treated with sodium azide had lower water levels than those that were not treated with water hyacinth. This can be due to the possible mutation of the gene of the plants as a result of the treatment with sodium azide.

Hydrogen ion concentration (pH)

There is no significant change in the pH levels from set-up day to the end of week two. A slight increase was observed from the set-up day to the end of the second week. The lowest pH value was observed on the set-up day in June to be 2.35 (A) and the maximum pH value was observed on the second week of September to be 7.95 (A). This result is in line with that of Moyo *et al.*, 2013 which observed that there was no drastic change in pH, but observed a slight increase in pH from 6.80 to 6.86 between the two respective points in their study. Statistical analysis shows that the increase in pH values is not significant. The increase in pH in this study is contrary to most of the results of other researchers who have demonstrated pH reduction in the water samples treated with water hyacinth. Wolverton and McDonald, 1979 have showed a pH which remained constant in their study on comparison of physico-chemical parameters in a lagoon covered with water hyacinth and without water hyacinth. There is significant difference in the pH values for crude oil contaminated values and non-crude oil contaminated water. The pH from both the crude oil contaminated water and the non-crude oil contaminated water both increased from set-up day to the end of week two. The pH values for the crude oil contaminated water are higher compared to those that are not crude oil contaminated. This may be due to the fact that more plants in the crude oil contaminated water died and brought about an increase in pH level of the water.

Biochemical oxygen demand (BOD)

The biochemical oxygen demand decreased from May to August and rose again from September to October. The month of July showed the lowest readings for BOD among all the treatments with the lowest reading being -21.7 in treatment D_2. This is in line with the studies by Kumari and Tripathi, 2015 who observed a decline in BOD while treating municipal waste water with water hyacinth plant. Valipour *et al.*, 2015 also observed a decline in BOD when treating domestic wastewater. The decline shows the uptake by the water hyacinth of the nutrients of the water and hence phytoremediation.

Dissolved oxygen

The level of DO in any water shows conditions of pollution level (Piyush *et al.*, 2019). This study shows that the highest DO was observed to be 59.9 in treatment D1 in week 1 in the month of August. The lowest DO was recorded as 6.9 in week two, treatment B in the month of September. Dar *et al.* (2011) and Shah *et al.* (2010) all observed increase in DO level whereas Mangas-Ramirez and Elias-Gutierrez (2004), Perna and Burrow (2005) found lower DO concentration beneath the test plant mats. The overall results showed that, there was an increase in DO concentration in all the treated wastewater samples.

Total dissolved solid

High TDS was recorded on the set-up day for all the treatments except the month of August that showed lower TDS result on set-up day. There was a significant decline in the TDS for all treatments in the study throughout the duration of the study except in August where there was an increase instead of a decline. This result is in line with the result by Gupta et al., 2019 who reported that Water hyacinth showed high TDS removal efficiency. This higher removal of solids could be attributed to the property particle sedimentation by the test plant (Gupta *et al*., 2015) or the ability of the plant root to retain coarse and fine particle, as well as organic materials present in ground water. A decrease in TDS leads to an increase in pH and decrease in electrical conductivity. Other researchers also observed a considerable reduction in the amount of TDS in treatment of waste water by water hyacinth (Borges et al., 2008; Gamage and Yapa, 2001). For drinking water standard (BIS, 1991), permissible limit of TDS is 500 mg/l. It has been observed that water hyacinth can bring the TDS level within the norms. It was observed that at after 10 days, the removal efficiencies varied from 36% to 65%, after that plants started dying. As a result, it is suggested that new plants can be added up in the treatment system to increase the rate of survival of the plants in the treatment in order to achieve the desired TDS concentration. The rate of reduction of the TDS by the plants that were treated with sodium azide (C, C_1, C_2, D, D_1 and D_2) is lower compared to plants that were not. Also, the treatments that were contaminated with crude oil, showed more reduction in TDS than those that were not contaminated with crude oil (Figure 1).

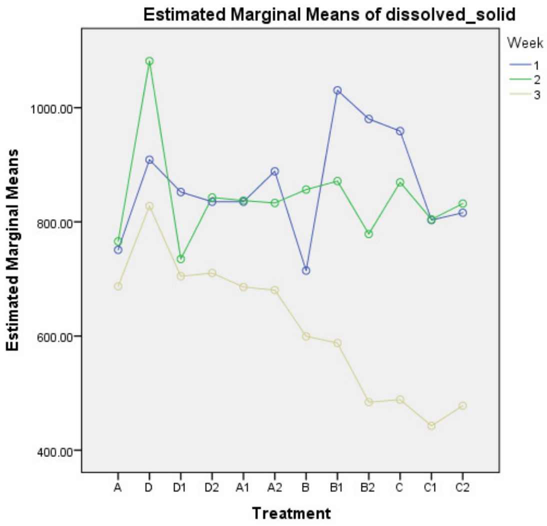

Figure 1: Total dissolve solid (TDS)

Electrical conductivity (EC)

The result showed that there was a significant increase in the EC from May to June by the first week and a sharp decline by the second week. The results from August to October showed a consistent decline in the Electrical Conductivity (EC) from both week one and week two. This difference can be due to the seasonal variation in the weather conditions from May to July and from August to October. The decline in EC is in line with the result obtained by Moyo et al., 2013 which also recorded a significant decrease in EC. The EC on the set-up day is not the same with the EC of the tap water because of the cooper solution that was used to prepare the hydroponic solution. Statistical analysis showed that the difference or decline in EC values from set-up day to week one suggests that water hyacinth is remediating the water, especially with regards to the ions present. The decline in EC levels was observed in both the water that were contaminated with crude oil and those that weren't contaminated with crude oil. There is no significant difference between the level of decline that was observed in the change in EC levels of the water that is contaminated with crude oil and the one that is contaminated with crude oil. Electrical conductivity is a parameter that is used in phytoremediation studies to measure pollution and provides an estimate of the concentration of ions as well as salts in water. A reduction in the EC values, as seen in the results of this study, is an indicator of remediation action by the plant. Mahmood et al., 2005 suggested that remediation action is achieved by assimilation of the pollutants by the plant. They noted a 55% decrease in in conductivity in conductivity in textile waste samples treated by water hyacinth within a 96-hour period. It should be noted that there was no significant decline in EC values for July from the set day to week two. The EC values for the crude oil contaminated water (B, B_1, B_2, C, C_1 and C_2) however showed a significant decline especially by week two after increasing in week one. This could be due to climate change before the onset of late rainfall and early dry season in August.

Survival studies

There was a significant decline in the survival rate of the plant from week one to week two. This can be due to the high TDS recorded from the set-up day of the experiment (Piyush *et al*., 2019). The statistical analysis revealed that the month of July showed the highest survival rate for week 1 with C2 showing the highest number of survival per treatment. The graph also revealed that all the plants that were treated with sodium azide (C, C_1, C_2, D, D_1 and

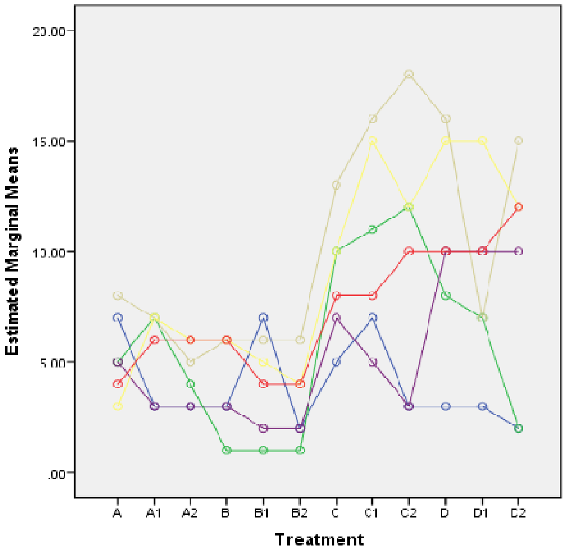

Figure 2a: Survival Studies result for week 1.

D_2) to induce beneficial mutation showed the highest survival rate compared to those that weren't treated with sodium azide. This suggests that the plants have become genetically modified to survive more especially when exposed to harsh conditions like crude oil pollution. Treatments B, B_1 and B_2 for the month of June in week 1, showed the lowest survival rate. This can be because the water was contaminated with crude oil and the plants were not treated with sodium azide to induce any beneficial mutation that could have increased their rate of survival (Figures 2a,b).

The highest survival rate was recorded in treatment D_2 in the month of August. All the plants that were treated with sodium azide showed high survival rate except in the month of May and June where low survival rate was recorded for treatment D, D_1 and D_2. This is consistent with the result for week 1 and may indicate that the concentration of the sodium azide solution used in treating the plant is not strong enough to induce beneficial mutation that can increase the plant survival rate. We can also deduce that the Lethal dose of sodium azide that can induce the plant survival result in water hyacinth is 0.05 mol/dm^3. It was observed that plants that were submerged under the water survived better than those that were on the surface of the water. Most of the leaves on the top of the water surface decomposed or dried up.

This could be due to the inability of their stems and roots to absorb the nutrient in the water and transport it to the leaves for photosynthesis as well as for proper growth of the plants. It could also be as a result of insufficient dissolved oxygen in the surface of the water in comparism to the natural habitat such as Jabi Lake where mixing of water occurs due to the activity of tides and waves, thereby making dissolved oxygen on the surface to be abundant (Figures 2a and b).

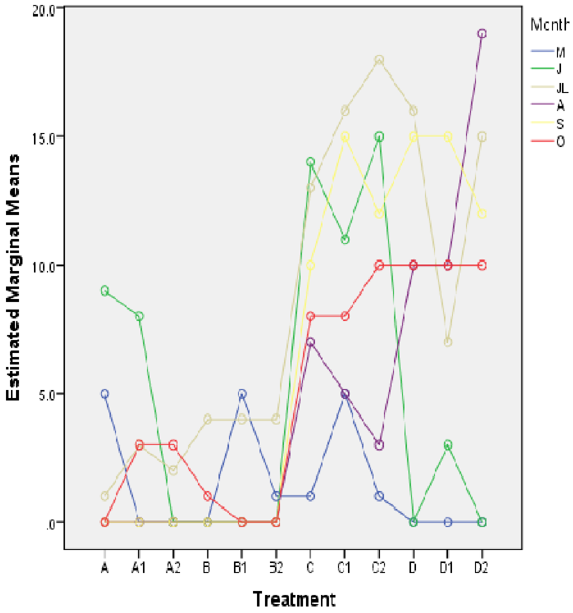

Figure 2b: Survival studies result for week 2.

BOD result

The highest BOD result was observed in the month of October with a value of 31.8 in treatment A_1, while the lowest value of BOD was observed to be -12.3 in treatment D_2 (Figures 3 and 4). Figure 3 shows the difference concentration used in the study, and the various months. In the treatment A1, the month of October recorded the highest and this is consistent throughout other months except in TREATMENT C1 and TREATMENT D2. Also, the month of September have high records in the Biological Oxygen Demand (BOD). The study also revealed the treatment A, A1, A2, B2, and C2 have higher records of values, while D2 and D1 have recorded the lowest values.

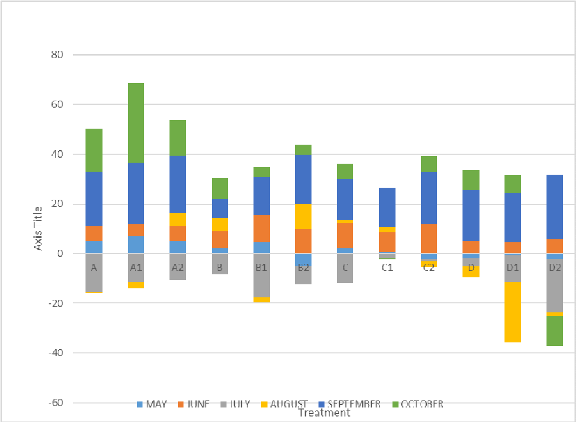

Figure 3: BOD result.

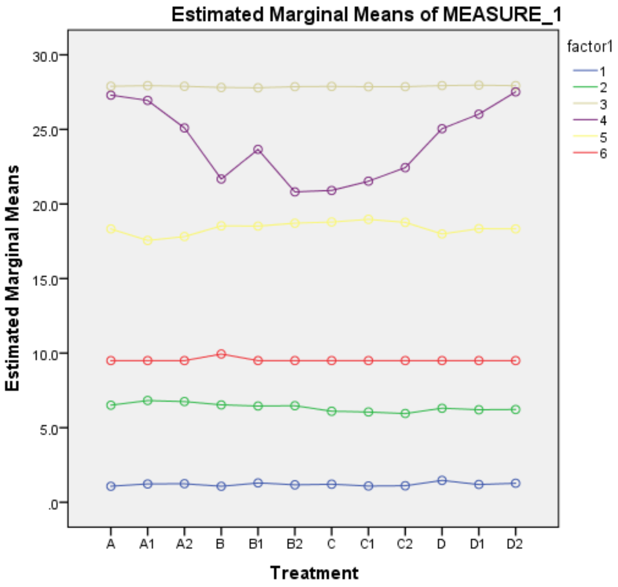

Figure 4: Estimate of means for BOD for May to October

Conclusion

The issue of crude oil contamination remains a very serious environmental threat that continues to pose a big threat to human life as well as the biodiversities in such areas. This research has focused on exploring the great potential of the biological approach of phytoremediation in proferring solution to this problem and also how genetics can be utilized in improving the potential of the plants in cleaning up environmental pollutants. Through the use of sodium azide, we have been able to induce beneficial mutation in the phytoremediation ability of water hyacinth which is commonly used in phytoremediation. We can therefore conclude that technics in genetics remains a viable tool to be able to improve the quality or ability of plants to absorp or take up metals and other contaminants that poses great threat to the environment. The result from this study also shows that contrary to the long time rate of plants to phytoremediate contaminated environments, through ideas in genetics can be used to speedy up the rate of phytoremediation. This is clearly depicted in the amount of Fe2+, Pb2+ and SO2+4 that was absorbed by the leaves of the plant. The result from the genetically modified plants showed high uptake and absorption rate of these ions, indicating that there is an increase in the rate of phytoremediation.

REFERENCES

Abbas Z., Arooj F., Ali S. Zaheer I. E. (2019). Phytoremediation Of Landfill Leachate Waste Contaminants Through Floating Bed Technique Using Water Hyacinth And Water Lettuce. International Journal of Phytoremediation, 21(1).

Abdulla S. (2002). Tobacco Sucks Up Explosives. Nature. https://www.nature.com/nsu/990429/990429-5.html

Abraham Ekperusi (2017). Ogoni cleanup: government, hyprep, mosop and the rest of us. htttps://www.thecable.ng

Adamu A. K. And Aliyu H. (2007). Morphological Effects Of Sodium Azide On Tomato (Lycopersicon Esculentum Mill). Science World Journal, 2(4):9-12.

Ali, H., Khan, E. And Sajad, M. A. (2013). Phytoremediation Of Heavy Metals–Concepts and Applications. Chemosphere, 91, 869 – 881.

Arslan M., Imran A., Khan Q. M. And Afzal M. (2017). Plant-Bacteria Partnership For The Remediation Of Persistent Organic Pollutants. Environmental Science Pollution Research 24, 4322-4336.

Acharya U., Mowen M.B., Nagashima K., Acharya J. K. (2004). Ceramidase Expression Facilitates Membrane Turnover And Endocytosis Of RhodopsinIn Photoreceptors. Proceedings Of The National Academy Of Sciences United States Of America, 101(7):1922 – 1926

Berkeowei R. Alexander and Ohwo Odafivwotu (2021). Phytoremediation of Physico-Chemical Parameters In Wastewater Effluents From Car Wash Bays In Yenagoa Metropolis, Nigeria.

Burges Alitz, Alkorta Itziar, Epelde and Garbisu Carlos (2018). Phytoremediation of soil contaminants to phytomanagement of ecosystem services in metal contamination sites. International Journal of Phytoremediation, 20:4, 384 – 397.

Busca G., Berardinelli S., Resini C. And Arrighi L. (2008). Technologies For The Removal Of Phenol From Fluid Streams: A Short Review Of Recent Developments. Journal Of Harzardous Materials, 160(2-3): 265-288.

Campos V. M., I. Merino, R. Casado, L. Pacious F. And L. Gomez (2008). Review. Phytoremediation Of Organic Pollutants. Spanish Journal of Agricultural Research, 6:38-47.

Cunningham, S. D. and Ow, D. W. (1996). Promises and Prospects of Phytoremedition. Plant Physiology, 110, 715 - 719.

Das N. And Chandran P. (2011). Microbial Degradation Of Petroleum Hydrocarbon Contaminants: An Overview. Biotechnology Research International, Article Id:941810. https://dx.doi.org/10.4061/2011/941810.

Daud M. K., Ali S., Abbas Z., Zaheer I. E., Riaz M. A., Malik A., Hussain A., Rizwan M., Zia-Ur-Rehman Muhammad, And Zhu S. J. (2018). Potential of Duckweed (Lemna Minor) For the Phytoremediation of Landfill Leachate. Hindawi Journal of chemistry, Volume 2018. Article ID 3951540, 9 pages.

De Stefani G., Tochetto D., Salvato M., and Borin M. (2011). Performance Of A Floating Treatment Wetland For In Stream Water Amelioration In NE Italy. Hydrobiologia, 674: 157 – 167.

Ebel M., Michael W. H., And Schaeffer (2007). Cyanide Phytoremediation by WaterHyacinths (Eichornia Crassipes). Chemosphere, 66:816-823.

Eze, J. J. and Dambo, A. (2015). Mutagenic Effects of Sodium Azide on the Quality of Maize Seeds. Journal of Advanced Laboratory Research in Biology, 6(3), 76 – 82.

Flathman P. E. And Lanza (1998). Phytoremediation: Current Views On An Emerging Green Technology. Soil And Sediment Contamination (Journal of Soil Contamination).7(4):415-432.

Gerhardt K. E., Gerwing P. D., And Greenberg B. M. (2017). Opinion: taking phytoremediation from proven technology to practice. Plant science. 256:170 -185.

Grutzka D., Szarejko I., Maluzynski M. (2012). Sodium Azide As A Mutagen. In: Shu Q.Y., Foster B.P., Nakagawa H. (Eds). Plant Mutation Breeding And Biotechnology. CABI, The United Kingdom, 159-166.

Hammad D. M. (2011). Cu, Ni Phytoremediation And Translocation By Water Hyacinth Plant At Different Aquatic Environments. Australian Journal of Basic And Applied Sciences, 5(11):11-22.

Hejna Monica, Moscatelli Alessandra, Onelli Elizabeth, Baldi Antonella, Stroppa Nadia, Pilu Salvatore And Rossi Luciana (2020). Bioaccumulation Of Heavy Metals From Wastewater Through A Typha Latifolia And Thelypteris.

Hounkpe S. P., Crapper M., Sagbo A., Adjovi E. And Aina M. P. (2022). Influence Of Ph On Water Hyacinth Ponds Treating And Recycling Wastewater. Journal Of Water Resource and Protection, 14:86-99.

Huang, J. W. and Cunningham, S.D. (1996). “Lead Phytoextraction: Species Variation in lead Uptake and Translocation,” The New

Phytologist, 134: (1): 75-84.

Ingole N. W. And Bhole A. G. (2003). Removal Of Heavy Metals From Aqueous Solution By Water Hyacinth (Eichornia Crassipes). Journal Of Water Supply: Research and Technology (Aqua), 52(2):119 – 128.

Jayaweera M. W. And Kasturiarachchi J. C. (2004). Removal Of Nitrogen And Phosphorus From Industrial Wastewaters By Phytoremediation, Using Water Hyacinth (Eichornia Crassipes (Mart) Solms). Water Science Technology, 50:217 – 225).

Khan Mumtaz, Shaheen Salma, Ali Shafaqat, Yi Zhang, Cheng Li, Khan Daud, Azam Muhammad, Rizwan Muhammad, Afzal Muhammed, Irum Ghazala, Khan Jamil Muhammed and Shuijin Zhu (2020). Insitu phytoremediation of metals. Phytoremediation:pp 10: 103 – 121.

Kiruki S., Onek L. A. And Limo M. (2009). Azide-Based Mutagenesis Suppresses Striga Hermonthica Seed Germination And Parasitism On Maize Varieties. African Journal Of Biotechnology, 5(10), 866-870.

Leguizamo M. A. O., Gomez W. D. F., Sarmiento M. C. G. (2017). Native Herbaceous Plant Species with Potential Use in Phytoremediation Of Heavy Metals, Spotlight On Wetlands – A Review. Chemosphere. 168:1230-1247.

Liao S. W. And Change W. L. (2004). Heavy Metal Phytoremediation By Water Hyacinth At Constructed Wetlands In Taiwan. Journal Of Aquatic Plant Management, 42: 60-68.

Lu J., Wu J., Fu Z., Zhu L. (2007). Water Hyacinth In China: A Sustainability Science-Based Management Framework. Environmental Management, 40: 823–830.

Mahalakshmi R., Sivapragasam C., Vanitha S (2019a). Comparison of BOD5 Removal In Water Hyacinth And Duckweed By Genetic Programming:Proceedings Of ICTIS 2018, Volume 1, Information And Communication Technology For Intelligent Systems (401- 408).

Mahalakshmi R., Sivapragasam C., Vanitha S (2019a). Comparison Of BOD5 Removal In Water Hyacinth And Duckweed By Genetic Programming: Proceedings Of ICTIS 2018, Volume 1, Information And Communication Technology For Intelligent Systems (401- 408).

Mapira J. (2011). Challenges Of Solid Waste Disposal And Management In The City Of Masvingo, Zimbabwe. Journal Of Sustainable Development In Africa, 13:181 – 194.

Martinez J. M. And Gomez B. M. A (2007). Integrated Control Of Eichornia Crassipes By Using Insects And Plant Pathogens In Mexico. Crop Protection, 26: 1234 – 1238.

Mason, C.F. (1981). Biology of Freshwater Pollution, longman.

Mensah J. K. And Obadoni O. (2007). Effects Of Sodium Azide On Yield Parameters Of Groundnut (Arachis Hypogea L.). African Journal Of Biotechnology, 6:20-25.

Mostafa, G.G. (2009). Effect Of Dimethyl Sulphonate On The Growth

And Some Chemical Compositions Of Balanites Aegyptiaca Delile. Alexandria Journal of Agricultural Research, 54:81-89.

Moyo P., Chapungu L. And Mudzenzi B. (2013). A Proposed Management Approach To The Control Of Water Hyacinth: The Case Of Shagashe River In Masvingo, Zimbabwe. Greener Journal Of Physical Sciences, 3(6):229 – 240.

Nazir A., Malik R. N., Ajab M., Khan N., And Siddiqui M. F. (2011). Hyperaccumulation Of Heavy Metals Of Industrial Areas Of Islamabad And Rawalpindi. Pakistan Journal of Botany, 43:1925-1933. Palustris Phytoremedition System. Chemosphere. Volume 24.

Pas-Alberto A. M. And Sigua G. C. (2013). Phytoremediation: A Green Technology To Remove Environmental Pollutants. Environmental Journal Of Climate Change, 2:71-86.

Perelo, L.W. (2010) Review: In situ and bioremediation of organic pollutants in aquatic sediments. Journal of Hazardous Material, 177: 81-89.

Pilon-Smits, E. (2005). “Phytoremediation”. Annual Review of Plant Biology, 56: (1): 15-39.

Reeves R. D., Baker A. J. M., Jaffre T., Erskine P. D., Echevarria G. and Ent. A (2017). A Global Database For Plants That Hyperaccumulate Metal And Metalloid Trace Elements. New phytologist, 218:407-411.

Rezania S., Ponraj M., Talaiekhozani A., Mohammed S. E., Din M. F. M., Taib S. M., Sabbagh, and Sairan F. M. (2015). Perspectives of Phytoremediation Using Water Hyacinth for Removal Of Heavy Metals, Organic And Inorganic Pollutants In Wastewater. Journal Of Environmental Management, 163:125-133.

Roongtanakiat, N., Tangruangkiat, S. And Meesat, R. (2007). Utilization of Vertiver Grass (Vertiveriazizanoides) For Removal of Heayy Metals From Industrial Waste waters., Science Asia, 33:397-403.

Roy, S. And Hanninen, O., 1994. Pentachlorophenol: Uptake/Elimination Kinetics And Metabolism In An Aquatic Plant, Eichornia Crassipes. Environmental Toxicology Chemistry, 13:763-773.

Saha P., Shinde Omkar And Sarkar S. (2017). Phytoremediation Of Industrial Mines Wastewater Hyacinth. International Journal Of Phytoremediation, 19:1, 87-96.

Salt D.E., Smith R.D., Raskin I (1998). "Phytoremediation". Annual Review of Plant Physiology and Plant Molecular Biology. 49: 643–668.

Singh N. and Balomajumder C. (2021). Phytoremediation Potential of Water Hyacinth (Eichornia crassipes) or Phenol and Cyanide Elimination from Synthetic (Simulated Wastewater). Applied Water Science (2021). 11;144 https://doi.org/10.1007/S13201-021-0472-8.

Singhai V. And Rai L. P. (2003). Biogas Production From Water Hyacinth And Channel Grass Used For Phytodrama; Edition Of Industrial Effluents. Bioresource Technology, 86:221–225. Https://Doi.Org/10.1016/50960-8524(02)00178-5.

Shahabaldin R., Ponraj M., Talaiekhozani A., Mohammed S. E., Mohd F. Md D., Taib S. M., Sabbagh F. and Sairan F. Md. (2015). Perspectives Of Phytoremediation Using Water Hyacinth For Removal Of Heavy Metals, Organic And Inorganic Pollutants In Wastewater. Journal Of Environmental Management 163(1): 125 – 133.

Shi Z., Liu J., Tang Z., Zhao Y. And Wang C. (2020). Vermiremediation Of Organically Contaminated Soils: Concepts, Current Status And Future Perpectives. Applied Soil Ecology, 147:1-11. Singhai V. And Rai L. P. (2003). Biogas Production From Water Hyacinth And Channel Grass Used For Phytodrama; Edition Of Industrial Effluents.Bioresource Technology, 86:221 – 225. Https://Doi.Org/10.1016/50960-8524(02)00178-5.

Srivastava P. Marker S., Pandey P., And D.K. Tiwari (2011). Mutagenic Effects Of Sodium Azide On Growth And Yield Characteristics In Wheat (Triticum Aestivum L. Em. Thel.). Asian journal of plant sciences, 10(3):190 – 201.

Subashchandrabose SR, Ramakrishnan B, Megharaj M, Venkateswarlu K, Naidu R. (2013). Mixotrophic cyanobacteria and microalgae as distinctive biological agents for organic pollutant degradation. Environment International. 51: 59-72.

Suresh B, Ravishankar GA (2004). Phytoremediation—A Novel and Promising Approach for Environmental Cleanup. Crit. Rev. Biotechnology, 24: 97–124.

Swain G., Adhika S. and Mohanty P. (2014). Phytoremediation of Copper And Cadmium From Water Using Water Hyacinth, Eichornia Crassipes. International Journal Of Agricultural Science And Technology (Ijast), 2(1):1-8.

Swarnalatha G. V., Hedge N. S., Chanhan V. S., Chauhan V. S., Sarada R. (2015). The Effect Of Carbondioxide Rich Environment On Carbonic Anhydrase Activity, Growth And Metabolite Production In Indigenous Fresh Water Microalgae. Algal Research, 9: 151 – 159.

Taylor D. J., Green N. P. O., and Stout, G.W. (2005). “Human Impacts on Ecosystems”, Biological Sciences, 3rd Edition, 326 – 332.Cambridge.

Tewes J. L., Stolpe C., Kerim A. Kramer U., Muller C. (2018). Metal Hyperaccumulation In The Brassicaceae Species Arabidopsis Helleri Reduces Camalexin Induction After Fungal Pathogen Attack. Environmental and experimental botany, 153:120-126.

United Nation Environmental Protection (UNEP) (2011). Environmental Assessment of Ogoniland.

Watanabe M. E. (1997). Phytoremediation On The Brink Of Commercialization. Environmental Sciences And Technology, 31:182-186. Hhttps://doi.org/10.1021/es972219s

Yadav K. K., Gupta N., Kumar A., Reece L. M., Singh N., Rezania S., Khan S. A. (2018). Mechanistic Understanding and Holistic Approach of Phytoremediation: A Review On Application And Future Prospects. Ecological engineering, 120: 274 – 298.

Yan A., Wang Y., Tan S. N., Yusuf M. L. M., Ghosh S. and Chen Z. (2020). Phytoremediation: a promising approach for revegetation of heavy metals-polluted land. Frontiers In Plant Science, doi: 10.3389/fpls.2020.00359.

Zayad A. M. And Terry N. (2003). Chromium In Environment: Factors Affecting Biological Remediation. Plant And Soil, 249:139-156. https://Doi.Org/10.1023/A:1022504826342.