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Contaminants Correlation and Curtailment Prospect of Water hyacinth, Water lettuce and Vetiver Grass in Wastewater Treatment

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Abstract

This study seeks to elaborate the correlation of physicochemical parameters and heavy metals from a wastewater effluent in Zaria. The contaminants reduction capacity of Vetiver grass (C. zizanoides), water hyacinth (E. crassipes) and Water lettuce (P.stratiotes) were analysed.Temperature, pH, EC, TDS, Cl, PO4-, DO, BOD, COD, Na, K, NO3, TSS, NH3, SO4 and Cu, Cd, Pb, Mn, Mg, Co, Ni, Cr and Zn concentrations were determined using standard method,digestion and assessment of heavy metals using atomic absorption spectrophotometry machine. There was positive correlation between TDS with EC, BOD with NO3-N, pH with Temperature, DO with COD and N, and Cl with K. Zn with Pb and Cd, Cr with Co indicating common source of contamination. Negative correlation was observed between HCO3 with NH3.N and SO4-, Temperature with N and DO, K with BOD and NO3-N, Cr with Ni, Mg with Cu and Zn indicating uncommon source of contamination. The significant correlation was verified by using t-test. The systematic calculation of correlation coefficient between water quality parameters and between heavy metals was carried out. Hydroponic method of phytoremediation was adopted to evaluate the curtailment potentials of the three plants.There was significant difference at $P \leq 0.05$ (95% confidence) across days 7, 14 and 21 in reduction during treatment with water hyacinth for EC (846.1, 699 .00 and 502.1 mg/L), TDS (410.5, 340.0 and 259.0 mg/l), NH3 (1.25, 1.04 and 0.84 mg/l) and Cd (0.021, 0.018 and 0.012 mg/l)., with vetiver grass for EC (828.2, 654.1 and 488.1mg/L), TDS (398.6, 282.8 and 198.2 mg/L), COD (476.5, 355.5 and 265.5 mg/L), NO3 (3.34, 2.13 and 1.40mg/L), TSS (11.6, 8.66 and 6.58mg/L) and Cd (0.019, 0.011 and 0.01mg/L)., and with water lettuce for EC (833.0, 709.6 and 587 mg/L), TDS (452.6, 404.0 and 284.0 mg/L), Cr (0.12, 0.10, and 0.79mg/L), Pb (0.21, 0.18 and 0.13mg/L) and Cd (0.019, 0.013 and 0.011 mg/l). Vetiver grass was found to be more prospective in the curtailment of contaminants.

Keywords: Correlation; Heavy metals; Hydroponic; Physicochemical factors; Phytoremediation; Wastewater

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1. Introduction

Clean water is essential for nature and humans alike. Estimates indicate that developing countries surface waters are subjected to vast pressures and may already be affected by severe pollution due to easy accessibility for disposal of wastewater (UN, 2019). Water characteristic is one of the vital issues in water asset administration (Sutadian et al., 2016). The release of high amounts of heavy metals into water bodies causes serious health and environmental challenges with the ability to accumulate in successive levels of the biological food chain which may lead to a rise in wastewater treatment cost (Ogoyi et al., 2011). Hospital wastewaters are major components of water, contributing to oxygen demand and nutrient loading of water bodies, elevating toxic algal bloom and leading to an unbalanced aquatic ecosystem (Wyasu and Okereke, 2012). It is significant that 70-80% of problems in developing countries are acknowledged with water pollution, especially affecting children. The toxic pollutants released in wastewaters can be harmful to aquatic organisms which also cause the regular waters to be unfit as usable water sources (Verla et al., 2018). Water pollution is a major global problem, therefore requiring ongoing assessment and amendment of water resource policy at all levels international down to individual aquifers and wells. The issue of social justice is compounding the water crisis; poor people are more likely to lack clean water and hygiene in comparison to rich one in related areas. Worldwide, enriching water safety, hygiene and sanitation could circumvent up to 9% of all diseases and 6% of all mortality cases (Kelland, 2017).

Water quality refer to the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a specified use. The quality of water is primarily guided by the scope and composition of dissolved solids present in it. The availability of good quality water is an imperative feature for preventing diseases and upgrading quality of life. It is necessary to know attributes about different physicochemical factors such as colour, taste, odour, TDS, pH, hardness, alkalinity, chlorides, fluoride, sulphate, iron, turbidity and nitrate used for testing of water quality (Bagalkar and Giri, 2017). An exceptional approach has been used to develop an arithmetic relationship for correlation of parameters and chemical contaminants.

Increasing discharge of heavy metals in water and soil from various sources is a matter of concern for safeguarding health and environment. Irrigation with heavy metal contaminated water such as Zn, Cd and Pb can deteriorate the quality of soil as well as the agricultural produce. The scenario of heavy metal contamination in water bodies has been analysed and the impact of heavy metals on various soil properties such as carbon mineralization, microbial biomass, enzymes activities, nitrogen fixation, pH and cation exchange capacity (CEC) has been appraised. Subsequently, metal amassment in crops has been scrutinized and in some cases higher concentrations of these heavy metals in edible part of crops was above the guidelines threshold assign by various government agencies and requires remediation (Gola et al., 2016). When physicochemical parameters and heavy metals concentrations exceed the maximum permissible level for potable water, such water is said to be contaminated (Izah and Srivastav, 2015). Water quality abatement involves understanding of data trends and seasonal variations in the physicochemical parameters of the water (Lemble et al., 2013).The application of green plants for phytoremediation is an environmentally friendly green technology, and an aesthetically acceptable removal mechanism that applies the potential of accumulation, extraction, filtration and degradation of contaminants from the polluted environment with basic information that comes from variety of research areas including constructed wetlands and oil spills (Sumiahadi and Acar, 2018). Many researchers have used different plant species like Water hyacinth

(Eichhornia crassipes (Mart. Solms), Water lettuce (Pistia stratiotes L.), vetiver grass (Chrysopogon zizanoides) for the treatment of different types of contaminated waters and effluents and recorded their efficiency (Valipour et al., 2011).

2. Materials and Method

2.1 Sampling

Water samples were taken from the effluent Ahmadu Bello University Teaching Hospital (ABUTH) wastewater treatment plant in Zaria. At the Sampling sites, the containers were rinsed several times with deionized water and rinsed three times with the wastewater before the samples were collected.

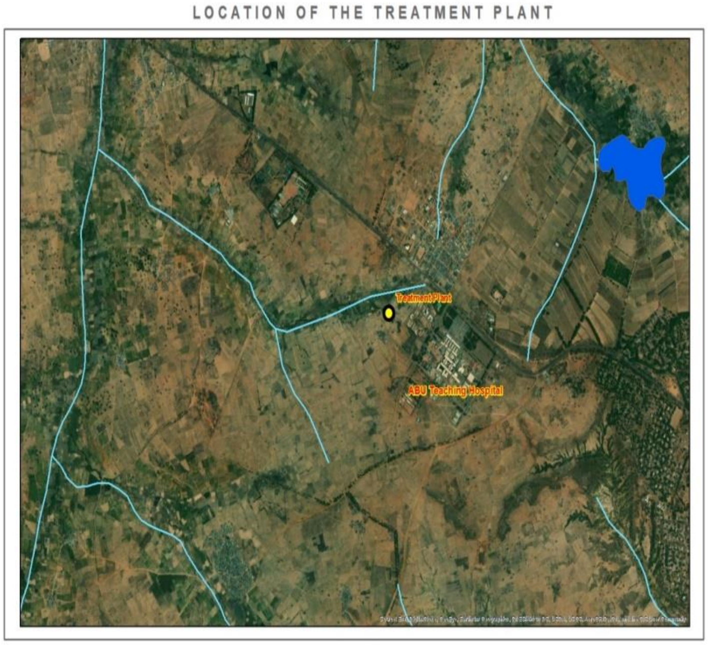

Figure 1: Map showing the location of the study site in Zaria, Kaduna State (Latitude 11^{o} 10’ 40’ N and 11^{o} 10’ 20’N of the equator and between Longitude 7^{o} 36’ 30’’ E and 7^{o} 36’ 0’’ E) of Greenwich meridian. (Source: GIS and Remote Sensing Lab Using ArcGIS 10.3 Software Department of Geography, ABU, Zaria. 2020)

2.2 Determination of Physicochemical Parameters

Temperature, pH, and EC were measured with pH meter (Jenway 3310), thermometer and conductivity meter (Hach model C0150). Winkler’s and Kjeldahl method for the remaining parameters in the laboratory as adopted using standard method for the examination of water and wastewater 23rd Edition (APHA, 2017). Statistical correlation analysis was performed using “Corrplot – R version 4.0.5”.

2.3 Heavy metals analysis

Water samples were collected in duplicates in the morning (between 7am-10am) from the Wastewater Treatment Plant (WWTP) of the hospital**.** Water was collected using the dip sampling method, which involves de-capping the prewashed bottles and dipping them below the surface till full. The wastewater samples were filtered through Whatman no. 541 filter paper (Whatman, Germany) into sampling tight capped bottles and pH was adjusted to 2 by treatment with approximately 3mL of 1:3 HNO_3: Deionized water per 250 mL sample before digestion was initiated (USGS,2006)

The samples were transported to central laboratory, Bayero University Kano (BUK), where they were preserved with HNO_3 to prevent metal precipitation and oxidation and kept at room temperature (25^0C). The samples were collected and stored such that degradation or alteration is minimized. The EPA vigorous digestion method described by APHA (2001) was adopted. Samples were allowed to stand in their original containers for 16 hours to allow potentially adsorbed metals to redissolve. Samples were well shaken to homogenize before digestion. The varying concentrations of Cadmium (Cd), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Magnesium (Mg), Manganese (Mn), Nickel (Ni), Lead (Pb), and Zinc (Zn) in the wastewater effluents were determined by Atomic Absorption Spectrophotometer (Model 4210, Agilent technology) according to APHA, (2001).

2.3 Hydroponic method of phytoremediation

2.3.1 Plants preparation

Young plants of water hyacinth (150g), water lettuce (50g) and vetiver grass (150g) were obtained and the roots of the plants were washed thoroughly with running tap water to remove adhering soil and sediments prior to use. The plants were acclimatized in distilled water for one week in the laboratory (Macek *et al.*, 2000)

2.3.2 Hydroponic settings

Six containers were filled with wastewater effluent to an effective depth of 0.35m for vetiver grass and a shallow depth of 0.25m for water hyacinth and water lettuce was used. Polystyrene rafts were set up for each replicate hydroponic treatment unit in a floating form to support vetiver tillers on waste water surface and on each floating platform, 6 holes of 10cm x10cm intervals were made which allowed the vetiver roots to be fully immersed. The 150gram vetiver grass was split carefully to (avoid damage to the roots) into tillers. Similar size healthy vetiver tillers were selected and pruned to 20cm for the shoots (stem and leaves) to reduce transpiration and 10cm for the roots. Each tiller was planted onto the hole in the platform foam. Water hyacinth and water lettuce plants were set directly afloat above the water level, while their roots grow down into the water column due to their buoyant structure (Macek *et al.*, 2000). Control unit were filled with waste water to an effective depth of 0.15m. The water hyacinth, water lettuce and vetiver grass planted in the floating form were left to grow for three (3 weeks) and the waste water were analyzed weekly. Dead shoots were replaced after monitoring for survival conditions (Calheirous *et al*., 2009).

2.2.3 Laboratory analysis of plant after remediation

At the end of the experiments, biomass of the three plants samples from each treatment unit of the waste water, was harvested from the water platform and transported to multi-user laboratory, chemistry department, Ahmadu Bello University, Zaria, laboratory for analysis.

The plants were cleaned to remove all the adhering material. The roots and shoots were separated, rinsed for 5mins under a running tap and shaken off. They were submerged in distilled water for 2mins, dried at 60^oC for 72hrs and milled to a fine powder (0.5 to 1.0mm) in a grinder. The grinded sample was analyzed for physicochemical parameters using standard method for water and waste water examination 23rd edition (APHA, 2017) and heavy metals by acid digestion and the use of Atomic Absorbance spectrophotometry (AAS) to determine the various parameters in the roots and shoots and also to assess the reduction capabilities of the three plants.

3. Results

3.1 Correlation Between Physicochemical Parameters

There was positive correlation between TDS with EC, BOD with NO_3-N, pH with Temperature, DO with COD and N, and Cl with K. indicating common source of contamination. Negative correlation was observed between HCO_3 with NH_3.N and SO_4^-, Temperature with N and DO, K with BOD and NO_3-N, indicating uncommon source of contamination.

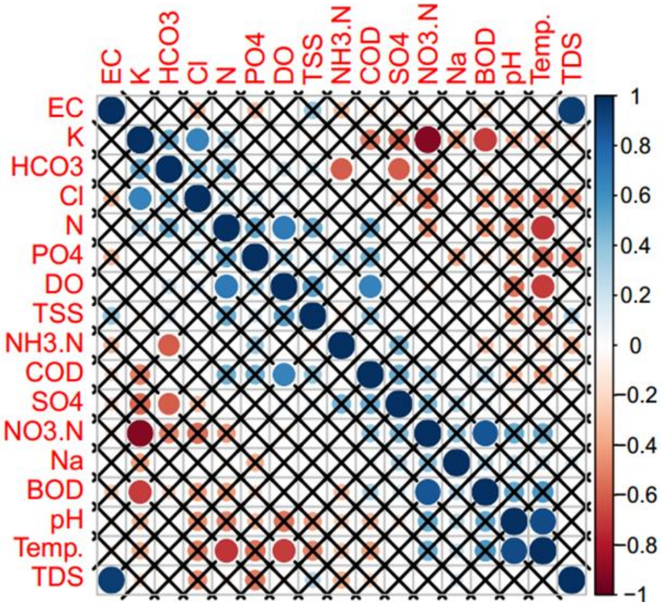

Fig 2: Correlation Between Physicochemical Parameters

3.2 Correlation of Heavy metal concentration

There was positive correlation between Zinc (Zn) with Pb and Cadmium (Cd), Chromium (Cr) with Cobalt (Co) while there was negative correlation between Cr with Nickel (Ni), Magnesium(Mg) with Copper (Cu) and Zn.

3.3 Reduction Potential of waterhyacinth in Phytoremediation of Physicochemical Parameters and Heavy metals Across Days

Table 1 showed that the mean variation in physicochemical parameters / Heavy metals in reduction potential by waterhyacinth.There was significant difference at $P \leq 0.05$ (95% confidence) across days 7, 14 and 21 in reduction during treatment for EC (846.1, 699 .00 and 502.1 mg/L), TDS (410.5, 340.0 and 259.0 mg/l), Cl (91.25, 77.25 and 61.25 mg/l).HCO3 (4.85, 3.56 and 2.75mg/l), DO (17.85, 18.40 and 19.85), NH_3 (1.25, 1.04 and 0.84 mg/l) and Cd (0.021, 0.018 and 0.012 mg/l). There was reduction potential observed on day 21.

Table 1: Mean variation in physicochemical parameters / Heavy metals in reduction potential by water hyacinth Across Days

PARAMETERS	**DAY 0**	**DAY 7**	**DAY 14**	**DAY 21**	**P-value**
Temperature	25 ± 0.00^{a}	22 ± 2.83^{a}	20.50 ± 2.12^{a}	19.50 ± 0.70^{a}	0.127
pH	7.65 ± 1.05^{a}	7.90 ± 0.84^{a}	8.25 ± 0.64^{a}	8.70 ± 0.28^{a}	0.589
EC	100.50 ± 10.18^{a}	846.10 ± 93.20^{a}	699 ± 60.81^{ab}	502.10 ± 14.2^{b}	0.012
TDS	535.50 ± 45.96^{a}	410.55 ± 45.8^{b}	340 ± 9.89^{bc}	259 ± 8.48^{c}	0.005
Cl	119.84 ± 14.61^{a}	91.25 ± 6.01^{ab}	77.25 ± 4.59^{b}	61.25 ± 3.18^{b}	0.009
PO_4	50.42 ± 16.85^{a}	42.25 ± 18.03^{a}	33.25 ± 13.78^{a}	25.75 ± 8.83^{a}	0.463
HCO_3	5.33 ± 0.18^{a}	4.85 ± 0.63^{ab}	3.56 ± 0.36^{bc}	2.75 ± 0.21^{c}	0.009
DO	16.40 ± 0.56^{c}	17.85 ± 0.07^{b}	18.40 ± 0.00^{b}	19.85 ± 0.07^{a}	0.001
BOD	172.82 ± 96.52^{a}	133.06 ± 63.53^{a}	109 ± 56.56^{a}	81.05 ± 48.01^{a}	0.595
COD	625 ± 134.35^{a}	487.55 ± 38.82^{a}	406 ± 86.26^{a}	325.50 ± 38.9^{a}	0.088
Na	91.06 ± 9.82^{a}	85.50 ± 14.84^{a}	64 ± 16.97^{a}	47.53 ± 2.07^{a}	0.071
K	35.16 ± 5.87^{a}	25.25 ± 7.42^{a}	19.85 ± 4.03^{a}	15.90 ± 4.11^{a}	0.089
NO_3	4.08 ± 0.77^{a}	3.79 ± 0.91^{a}	2.895 ± 0.31^{a}	1.96 ± 0.19^{a}	0.078
N	1.035 ± 0.12^{a}	0.89 ± 0.19^{a}	0.715 ± 0.21^{a}	0.555 ± 0.12^{a}	0.158
TSS	17 ± 2.83^{a}	13.55 ± 3.60^{a}	11.2 ± 2.96^{a}	8.645 ± 2.19^{a}	0.164
NH_3	1.53±0.00a	1.25 ± 0.08^{b}	1.04 ± 0.07^{bc}	0.845 ± 0.03^{c}	0.001
SO_4	35.15 ± 25.66^{a}	27.51 ± 21.89^{a}	19.97 ± 14.03^{a}	16.105 ± 11.58^{a}	0.769
Co	0.025 ± 0.00^{a}	0.02 ± 0.00^{a}	0.018 ± 0.00^{a}	0.015 ± 0.00^{a}	0.145
Cr	0.16 ± 0.01^{a}	0.135 ± 0.04^{a}	0.129 ± 0.04^{a}	0.119 ± 0.06^{a}	0.831
Cu	0.0995 ± 0.04^{a}	0.084 ± 0.02^{a}	0.078 ± 0.01^{a}	0.063 ± 0.00^{a}	0.582
Mg	77.94 ± 13.51^{a}	69.05 ± 3.40^{a}	59.86 ± 9.35^{a}	52.91 ± 18.12^{a}	0.331

Mn	0.295±0.04^{a}	0.226±0.12^{a}	0.21±0.13^{a}	0.199±0.14^{a}	0.852
Ni	0.1655±0.07^{a}	0.135±0.03^{a}	0.113±0.02^{a}	0.095±0.01^{a}	0.497
Pb	0.247±0.00^{a}	0.187±0.00^{a}	0.0775±0.00^{a}	0.121±0.00a	0.120
Zn	2.94±0.35^{a}	2.51±0.90^{a}	2.27±1.18^{a}	2.07±1.35^{a}	0.847
Cd	0.03±0.00^{a}	0.021±0.00^{b}	0.018±0.00^{c}	0.012±0.00^{b}	0.000

Note: Means with different alphabets across the rows are significantly different at $p \leq 0.05$.

KEY: EC= Electrical conductivity**,** TDS = Total Dissolved Solids, DO = Dissolved oxygen, BOD = Biological oxygen demand, COD = Chemical oxygen demand, NO$_3$ = Nitrate, TSS = Total suspended solids, NH$_3$ = Ammonia, SO$_4$ = Sulphate, Co =Cobalt, Cr= Chromium, Cu= Copper, Mg=Magnesium, Ni= Nickel, Pb= Lead, Zn= Zinc, Cd= Cadmium

3.4 Reduction Potential of Vetiver Grass in Phytoremediation of Physicochemical Parameters and Heavy metals Across Days.

Table 2 showed the mean variation in physicochemical parameters / Heavy metals in reduction potential by vetiver grass. There was significant difference at $P \leq 0.05$ (95% confidence) across days 7, 14 and 21 in reduction during treatment for EC (828.2, 654.1 and 488.1mg/L), TDS (398.6, 282.8 and 198.2 mg/L), Cl (88.3, 68.2 and 46.7 mg/L), HCO$_3$ (4.56,3.32 and 2.14), COD (476.5, 355.5 and 265.5 mg/L), Na (69.5, 51.0 and 33.5 mg/L), K(23.5, 16.6 and 13.4), NO$_3$ (3.34, 2.13 and 1.40mg/L), TSS (11.6, 8.66 and 6.58mg/L), NH$_3$ (1.19, 0.99 and 0.72mg/L), Mg 958.6, 41.6 and 29.1mg/L),Mn (0.22, 0.18 and 0.11mg/L), Zn (2.43, 2.09 and 1.1mg/L) and Cd (0.019, 0.011 and 0.01mg/L). Highest reduction significance was observed with vetiver grass.

Table 2: Mean variation in physicochemical parameters / Heavy metals in reduction potential by vetiver grass across days

Note: Means with different alphabets across the rows are significantly different at $p \leq 0.05$.

PARAMETERS	**DAY 0**	**DAY 7**	**DAY 14**	**DAY 21**	**Pvalue**
Temperature	25±0.00^{a}	22±2.83^{a}	20.50±2.12^{a}	19.50±0.71^{a}	0.127
pH	7.64±1.05^{a}	9.58±1.41^{a}	9.050±1.91^{a}	9.85±1.34^{a}	0.524
EC	1008.5±108.19^{a}	828.28±145.3^{b}	654.10±80.46^{ab}	488.15±33.73^{b}	0.025
TDS	535.50±45.96^{a}	398.65±34.43^{ab}	282.80±38.46^{bc}	198.25±26.51^{c}	0.003

Cl	119.84 ± 14.61^{a}	88.36 ± 5.88^{ab}	68.25 ± 8.83^{b}	46.78 ± 10.64^{b}	0.009
PO4	50.42 ± 16.85^{a}	52.98 ± 33.75^{a}	37.16 ± 22.54^{a}	23.6 ± 7.49^{a}	0.579
HCO3	5.33 ± 0.18^{a}	4.56 ± 0.63^{ab}	3.32 ± 0.31^{bc}	2.14 ± 0.00^{c}	0.003
DO	16.4 ± 16.40^{a}	18.38 ± 18.30^{a}	19.20 ± 19.20^{a}	21.15 ± 21.15^{a}	0.139
BOD	172.82 ± 86.52^{a}	123.63 ± 64.16^{a}	99.05 ± 59.32^{a}	74.06 ± 53.65^{a}	0.56
COD	625 ± 135.35^{a}	476.58 ± 47.38^{ab}	355.50 ± 59.32^{ab}	265.50 ± 53.65^{b}	0.037
Na	91.06 ± 9.82^{a}	69.58 ± 6.36^{ab}	51.05 ± 7.00^{bc}	33.56 ± 6.44^{c}	0.006
K	35.16 ± 5.87^{a}	23.55 ± 6.29^{ab}	16.66 ± 3.47^{ab}	13.40 ± 4.38^{b}	0.045
NO_3	4.08 ± 0.71^{a}	3.38 ± 0.63^{ab}	2.13 ± 0.42^{ab}	1.40 ± 0.18^{b}	0.023
N	1.04 ± 0.12^{a}	0.89 ± 0.21^{a}	0.685 ± 0.21^{a}	0.45 ± 0.21^{a}	0.084
TSS	17 ± 2.80^{a}	11.65 ± 0.91^{ab}	8.66 ± 0.76^{b}	6.58 ± 0.74^{b}	0.01
NH_3	1.53 ± 0.00^{a}	1.195 ± 0.12^{b}	0.99 ± 0.04^{bc}	0.72 ± 0.04^{c}	0.001
SO_4	35.15 ± 25.66^{a}	25.50 ± 16.68^{a}	17.56 ± 12.07^{a}	13.33 ± 10.28^{a}	0.637
Co	0.03 ± 0.00^{a}	0.02 ± 0.00^{a}	0.019 ± 0.00^{a}	0.01 ± 0.00^{a}	0.125
Cr	0.16 ± 0.01^{a}	0.12 ± 0.01^{a}	0.528 ± 0.62^{a}	0.06 ± 0.02^{a}	0.51
Cu	0.09 ± 0.06^{a}	0.066 ± 0.05^{a}	0.058 ± 0.05^{a}	0.04 ± 0.02^{a}	0.758
Mg	77.94 ± 13.51^{a}	58.62 ± 10.57^{ab}	41.605 ± 2.11^{b}	29.18 ± 2.81^{b}	0.019
Mn	0.29 ± 0.03^{a}	0.22 ± 0.00^{ab}	0.181 ± 0.05^{ab}	0.11 ± 0.00^{b}	0.02
Ni	0.20 ± 0.02^{a}	0.16 ± 0.04^{a}	0.12 ± 0.00^{a}	0.09 ± 0.06^{a}	0.051
Pb	0.25 ± 0.00^{a}	0.126 ± 0.00^{a}	0.104 ± 0.00^{a}	0.08 ± 0.00^{a}	0.48
Zn	2.94 ± 0.35^{a}	2.43 ± 0.29^{a}	2.0925 ± 0.06^{a}	1.10 ± 0.12^{b}	0.007
Cd	0.03 ± 0.00^{a}	0.019 ± 0.00^{b}	0.011 ± 0.00^{c}	0.01 ± 0.00^{c}	0.000

KEY: EC= Electrical conductivity, TDS = Total Dissolved Solids, DO = Dissolved oxygen, BOD = Biological oxygen demand, COD = Chemical oxygen demand, NO_3 = Nitrate, TSS = Total suspended solids, NH_3 = Ammonia, SO_4 = Sulphate, Co =Cobalt, Cr= Chromium, Cu= Copper, Mg=Magnesium, Ni= Nickel, Pb= Lead, Zn= Zinc, Cd= Cadmium

3.5 Reduction Potential of Waterlettuce in Phytoremediation of Physicochemical Parameters and Heavy metals Across Days.

Table 3 shows the mean variation in physicochemical parameters / Heavy metals in reduction potential by waterlettuce. There was significant difference at $P \leq 0.05$ (95% confidence) across days 7, 14 and 21 in reduction during treatment for EC (833.0, 709.6 and 587 mg/L), TDS (452.6, 404.0 and 284.0 mg/L), Cl (94.3, 79.8 and 63.8 mg/L), HCO_3 (5.01, 3.80, 2.85 mg/L), Na (77.0, 64.0 and 49.0 mg/L), NH_3 (1.28, 1.07, and 0.91 mg/L), Cr(0.12, 0.10, and 0.79mg/L), Mg (59.2, 45.2 and 37.6 mg/L), Mn (0.23, 0.20 and 0.15 mg/L), Pb (0.21, 0.18 and 0.13mg/L), Zn (2.42, 2.01,and 1.27 mg/L) and Cd (0.019, 0.013 and 0.011 mg/l) with highest reduction capacity during the final week.

Table 3 Mean variation in physicochemical parameters / heavy metals in reduction potential by water lettuce across Days

PARAMETERS	DAY 0	DAY 7	DAY 14	DAY 21	P value
Temperature	25 ± 0.00^{a}	23 ± 1.41^{a}	22.25 ± 1.77^{a}	20.50 ± 2.12^{a}	0.166
pH	7.645 ± 1.05^{a}	7.85 ± 0.78^{a}	8.20 ± 0.56^{a}	8.60 ± 0.14^{a}	0.607
EC	100.50 ± 108.1^{a}	833.05 ± 39.52^{ab}	709.65 ± 40.09^{b}	587.60 ± 47.23^{b}	0.012
TDS	535.50 ± 45.96^{a}	452.60 ± 84.00^{ab}	404 ± 36.76^{ab}	284 ± 36.77^{b}	0.041
Cl	119.835 ± 14.62^{a}	94.32 ± 11.56^{ab}	79.80 ± 8.06^{ab}	63.80 ± 5.23^{b}	0.024
PO_4	50.42 ± 16.86^{a}	40.76 ± 14.50^{a}	33.70 ± 8.90^{a}	27.35 ± 8.13^{a}	0.41
HCO_3	5.33 ± 0.18^{a}	5.01 ± 0.57^{a}	3.80 ± 0.4^{ab}	2.85 ± 0.21^{b}	0.009
DO	16.40 ± 0.56^{a}	18.20 ± 0.98^{a}	18.70 ± 1.13^{a}	19.80 ± 1.55^{a}	0.144
BOD	172.80 ± 86.54^{a}	143 ± 71.98^{a}	125.10 ± 64.62^{a}	98.10 ± 58.93^{a}	0.769
COD	625 ± 134.35^{a}	533.70 ± 78.21^{a}	430.30 ± 94.32^{a}	323.35 ± 77.28^{a}	0.13
Na	91.055 ± 9.82^{a}	77 ± 1.41^{ab}	64 ± 5.66^{bc}	49 ± 2.83^{c}	0.008
K	35.155 ± 5.87^{a}	26.10 ± 7.21^{a}	21.30 ± 3.95^{a}	17.32 ± 4.55^{a}	0.113
NO_3	4.08 ± 0.71^{a}	3.98 ± 1.14^{a}	2.85 ± 0.98^{a}	2.33 ± 0.52^{a}	0.266
N	1.035 ± 0.12^{a}	0.88 ± 0.15^{a}	0.725 ± 0.12^{a}	0.59 ± 0.07^{a}	0.075
TSS	17 ± 2.83^{a}	14.725 ± 1.87^{a}	12.02 ± 2.09^{a}	9.75 ± 1.90^{a}	0.104
NH_3	1.53 ± 0.00^{a}	1.28 ± 0.09^{b}	1.075 ± 0.06^{bc}	0.91 ± 0.02^{c}	0.002
SO_4	35.15 ± 25.66^{a}	30.105 ± 24.17^{a}	24.95 ± 19.72^{a}	31.05 ± 0.07^{a}	0.964
Co	0.145 ± 0.16^{a}	0.0225 ± 0.00^{a}	0.019±0.00a	0.015 ± 0.00^{a}	0.414
Cr	0.158 ± 0.01^{a}	0.127 ± 0.00^{ab}	0.1085 ± 0.01^{bc}	0.079 ± 0.00^{c}	0.005
Cu	0.087 ± 0.05^{a}	0.075 ± 0.05^{a}	0.0615 ± 0.04^{a}	0.0425 ± 0.03^{a}	0.81
Mg	77.94 ± 13.51^{a}	59.285 ± 5.83^{ab}	45.21 ± 2.73^{b}	37.62 ± 3.51^{b}	0.022
Mn	0.2875 ± 0.03^{a}	0.233 ± 0.00^{ab}	0.2005 ± 0.01^{bc}	0.1545±0.00c	0.007
Ni	0.199 ± 0.02^{a}	0.169 ± 0.04^{a}	0.1285 ± 0.00^{a}	0.1105 ± 0.01^{a}	0.079
Pb	0.247 ± 0.00^{a}	0.216 ± 0.00^{b}	0.187 ± 0.00^{c}	0.136 ± 0.00^{b}	0.000
Zn	2.9395 ± 0.35^{a}	2.427 ± 0.58^{ab}	2.012 ± 0.22^{ab}	1.2785 ± 0.22^{b}	0.046
Cd	0.03 ± 0.00^{a}	0.019 ± 0.00^{b}	0.013 ± 0.00^{c}	0.011 ± 0.00^{b}	0.000

Note: Means with different alphabets across the rows are significantly different at $p \leq 0.05$.

KEY: EC= Electrical conductivity, TDS = Total Dissolved Solids, DO = Dissolved oxygen, BOD = Biological oxygen demand, COD = Chemical oxygen demand, NO_3 = Nitrate, TSS = Total suspended solids, NH_3 = Ammonia, SO_4 = Sulphate, Co =Cobalt, Cr= Chromium, Cu= Copper, Mg=Magnesium, Ni= Nickel, Pb= Lead, Zn= Zinc, Cd= Cadmium.

Discussion

In this study there was positive correlation between TDS with EC, BOD with NO_3-N, pH with Temperature, DO with COD and N, and Cl with K. Zinc (Zn) with Pb and Cadmium (Cd), Chromium (Cr) with Cobalt (Co) indicating common source of contamination. Negative correlation was observed between HCO_3^- with NH_3.N and SO_4^-, Temperature with N and DO, K with BOD and NO_3-N, Cr with Nickel (Ni), Magnesium (Mg) with Copper (Cu) and Zn indicating uncommon source of contamination. Therefore, correlation analysis in this study oppose the findings of Kiros *et al*. (2021) recorded the statistical Pearson's correlation analysis on the water quality parameters in the "Assessment of some physicochemical parameters and heavy metals in hand-dung well water samples of Kafta Humera Woreda, Tigray, Ethiopia, and revealed that all parameters are more or less correlated with each other. Electrical conductivity and total dissolved solids of the water samples were found to be significantly correlated with total hardness ($r = 0.989$), total alkalinity ($r = 0.827$), calcium ($r = 0.988$), magnesium ($r = 0.881$), sodium ($r = 0.995$), potassium ($r = 0.996$), chloride ($r = 0.998$), sulfate ($r = 1$), and nitrate ions ($r = 0.972$), as oppose to the findings in this study, possibly due difference in water sources. All other parameters were insignificantly different in concentration both in dry and wet season.

Indu *et al*., (2015) findings in a study on the physicochemical parameters and correlation analysis of surface water of Nawabganj Lake has a different outcome from this study. The databases obtained in his study were subjected to Pearson correlation matrix. Correlation coefficients revealed positive and significant correlations between the pairs of physicochemical parameters and metals in surface water. The major variations are related to anthropogenic activities (irrigation agricultural, construction activities, clearing of land, and domestic waste disposal). This result corresponds with the findings of Jackson *et al.,* (2020) in his research on the seasonal variations of physicochemical and nutrient water quality of river Tano in Ghana. This is due to common source of contamination. However, the findings contradict with that of Narendra and Kapil, (2007) in a correlation study on physicochemical parameters and quality assessment of Kosi river water, Uttarakhand where there was positive correlation between Cl with Mg, Na, pH and TSS and negative correlation between K with Cl, EC and $HCO_3^{-.}$ This may be due to different in season, location and the constituent of wastewater which differs from river waters.

Phytoremediation results recorded in this study shows there was significant difference at 95% confidence ($p \leq 0.05$) across the days 7, 14 and 21 in reduction during treatment with water hyacinth for EC (846.1, 699 .00 and 502.1 mg/L), TDS (410.5, 340.0 and 259.0 mg/l) and Cd (0.021, 0.018 and 0.012 mg/l)., with vetiver grass for EC (828.2, 654.1 and 488.1mg/L), TDS (398.6, 282.8 and 198.2 mg/L), COD (476.5, 355.5 and 265.5 mg/L), TSS (11.6, 8.66 and 6.58mg/L, Zn (2.43, 2.09 and 1.1mg/L) and Cd (0.019, 0.011 and 0.01mg/L)., and with lettuce for EC (833.0, 709.6 and 587 mg/L), TDS (452.6, 404.0 and 284.0 mg/L), Cr (0.12, 0.10, and 0.79mg/L), Pb (0.21, 0.18 and 0.13mg/L), Zn (2.42, 2.01,and 1.27 mg/L) and Cd (0.019, 0.013 and 0.011 mg/l). Vetiver grass was found to be more prospective in the curtailment of contaminants in wastewater due to its tolerance to toxic pollutants, stress, root length, high biomass and ability to withstand harsh conditions. Similar findings was also reported by Rupali *et al*. (2013) in phytoremediation potential of vetiver grass [*Chrysopogon zizanoides* (L.)] for tetracycline from aqueous media. Vetiver grass was grown for 60 days in greenhouse in TC contaminated hydroponic system. The complete removal of tetracycline occurred within 40days. It was concluded that vetiver grass is cost effective and can be used to remove antibiotics from wastewater. Also Alina and Sadhana, (2017); found the potentials of vetiver grass in percentage reduction above 50% for wastewater treatment and recorded reduction of Nitrate by 40.90%, BOD 71.03%, Cl 93.93%, and also Phosphate 88.4%. Potentials of vetiver grass over other plants was reviewed by Samuel (2018) in the comparative advantage of vetiver grass for the phytoremediation of heavy metals contaminants, and vetiver grass has the highest potential against *Sedum alfredii* and *Rumex crispus* as also recorded in this study where Vetiver grass has higher potential than water hyacinth and water lettuce. But the result findings of Gupta *et al*. (2015) in the study of the treatment of ground water using phytoremediation technique at Kolar Gold Fields, India revealed that water hyacinth had higher contaminant reduction capacity than water lettuce and could be due to less contaminants concentration in groundwater as oppose to hospital waste water used in this study which are toxic and hinder the extraction ability of water lettuce.

Conclusion

During the correlation analysis the result showed variability in both positive and negative correlations with temperature having strong negative correlation with D.O. and positive correlation between Zn with Pb and Cd. Vetiver grass had the highest potential with higher reduction efficiency followed by water hyacinth and then water lettuce and hence significant reduction of contaminants was recorded after phytoremediation. The three plants showed contaminant curtailment capacity and can therefore be adopted for phytoremediation processes in polluted environment.

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