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Phytoremedial Potential of *Phragmites karka* for the Treatment of Domestic Wastewater in Constructed Wetland at Gwalior, M.P.

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ABSTRACT

The geographical disparities between centers of population growth, the ecological degradation and availability of water, the water scarcity became an issue to overcome the problem. The present work is about the remedial potential of *Phragmites karka* for domestic wastewater treatment in a constructed wetland at Gwalior, M.P. The physiochemical parameters were taken into consideration after the introduction of the said plants into the study area (constructed wetland) and variation in these parameters in a period of six months per year were recorded. The physiochemical parameters which were studied, pH, Electrical Conductivity (EC), dissolved oxygen (DO), Biological Oxygen Demand (BOD), Total Hardness (TH), Chlorides (Cl^-), Nitrates (NO_3-N), and Phosphates (PO_4^{3-}). The heavy metals like iron (Fe) and Zinc (Zn) were detected by Atomic absorption spectroscopy (AAS). The changes were observed in parameters during the study period and also variation in the content of Fe and Zn was observed. There was a minor change in pH however there was a large increment in DO. The said plants had shown a great efficiency for the reduction of pollutants and extraction of heavy metals in comparison to a lot of already suggested hyperaccumulator plants.

Keywords: Constructed wetland, Wastewater, *Phragmites karka*, Hyperaccumulator

INTRODUCTION

Water is a free gift of nature to human being and its availability in terms of its quality is now becoming a problem for living world. Water is the source of life and basic need for human survival (Trivedi 2008). Water shortage arises primarily by the growing demand for clean water due to increased population, changing lifestyles, diminishing water resources and urbanization (Black, 2016). Wastewater derived from human activities in households such as dish washing, garbage disposal, toilets, bathroom, laundry, etc. is called as Domestic Wastewater (Eriksson *et al.,* 2002). DWW usually contains fairly small amounts of contaminants but small amount of pollutants can make a big impact on environment. Wastewater treatment ensures that proper treatment is safe, clean and suitable for releasing back into the environment (Qasim, 2017). Treated wastewater could be reused for irrigation as it is a common practice in many countries and is encouraged by governments and official entities (Becerra-Castro *et al.,* 2015). The main features of natural wastewater treatments are simple in construction, cost effective, efficient and reliable.

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Constructed wetland treatment systems are engineered systems that have been designed and constructed to utilize the natural processes of wetland vegetation, soils, and their associated microbial assemblages in order to assist wastewater treatment. They are also called constructed filtration systems planted with wetland vegetation which relies on natural physical, chemical and biological processes of natural wetlands (Vymazal, 2010). The remediation of pollution within wetlands includes sedimentation, coagulation, adsorption, filtration, biological uptake and microbial transformation (El-Khateeb *et al.,* 2008).

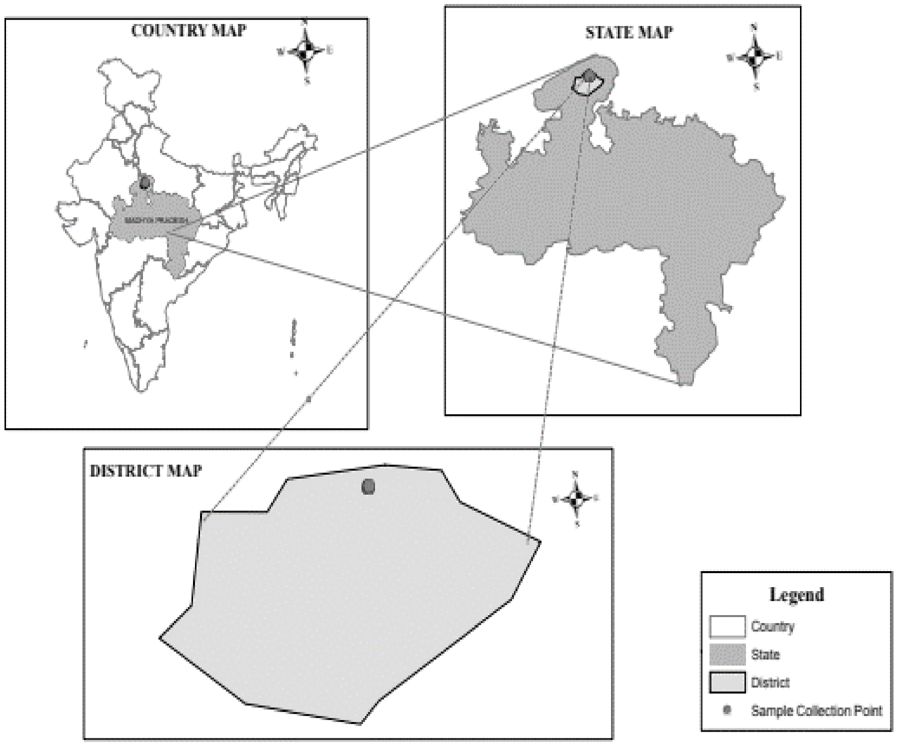

Fig. 1: Location map of the study area.

Heavy metals are noted as the hazardous contaminants in industrial effluents and their release into aquatic environment pose threat to flora, fauna, and human population (Khan *et al.,* 2013). Aquatic macrophytes are used as the natural catalysts to adsorb, absorb and accumulate heavy metals in their tissues from heavy metal polluted water (Vymazal, 2008). India, like other developing countries, also requires economical and cost-effective alternatives for wastewater treatment. According to the physiological and biochemical studies, plants are equipped with remarkable metabolic processes and absorption capabilities. They can selectively take up nutrients or contaminants from the soil or water which is required by them during its growth period (Isah, 2019). This plant based remedial approach absorbs elements and compounds from contaminated sites and metabolize them in their tissues. These macrophytes are then subsequently harvested, processed and disposed (Paz-Alberto *et al.,* 2013). The macrophytes with strong absorption for pollutants and good tolerance could be planted in constructed wetlands which accordingly removes or fix water pollutants through adsorption, absorption, accumulation and degradation (Wang *et al*., 2012). Environmental researchers have identified and realized some of the plant species which can accumulate huge amounts of contaminants. *Phragmites karka* (Retz) Trin. ex Steud (Family Poaceae) forms extensive masses of vegetation which are important for feeding and breeding habitat for fish (Kumar *et al.,* 2011). It is cosmopolitan in nature, mostly spreads naturally and can be propagated through division and seed (Burkill, 1994). The present study was done to evaluate the impact of *P. karka* on domestic wastewater. The limited rain water and surface runoff needs to be conserved means to ensure the availability of water throughout the year in Gwalior region.

Fig. 2: Preparation of Wetland with plants.

Fig. 3: Treatment of wastewater in Wetland with *Phragmites karka*

Fig. 4: Collection of Treated Water.

MATERIALS AND METHODOLOGY

Gwalior is located at 26.22^0 north 78.18^0 East in northern M.P. The maximum temperature may go upto 47^0C during summers and minimum temperature of 8.5^0 C during winters (Koul *et al.,* 2012). The present work on remediation of pollutants from DWW by *P. karka* in wetland technology was carried out at School of Studies in Botany, Jiwaji University Gwalior at Charak Udhyan (Medicinal plants Garden) near Mahalgaon, City center Gwalior M.P (Fig.1). The constructed wetland was properly designed with a basin that holds the water, a substratum for holding the root system of plants. The volume of each Constructed Wetland was 3m3 (1m x 2m x 1.5m) height, length and breadth respectively (Fig. 2). The wastewater from open drainage of Mahalgaon was collected in a Settling tank of 750 liters (Fig. 3). The influent from settling tank acts as inlet for two treatment plants, *viz.* Constructed wetland without plants (CWWP) and Constructed wetland planted with *Phragmites karka* (CWPK). Inlet from settling tank was applied at the top of the experimental units for the treatment. The effluent from those setups was collected from the bottom of the unit by outlet pipe (Fig. 4). The various parameters of untreated and treated water were analyzed by standard methods of APHA (2005, 2012). There was a great focus on the treatment performance of these treatment beds. Samples were collected into distilled sterile 2-L polyethylene bottles and after collection those samples were immediately transported to the laboratory. Periodic performance of the system was evaluated by analyzing the before treatment and after treatment. A Digital electronic pH meter and conductivity meter (Jackson, 1967) were used for the calculation of pH and Electrical Conductivity (EC). The electrode was washed with distilled water on every reading. The dissolved oxygen (DO) and biological oxygen demand BOD were analyzed by Winkler's Azide method. Total Solids were calculated by gravimetric evaporation determination method (APHA, 2012). The total hardness of Water samples were calculated by EDTA titrimetric method (APHA 2005). The chlorides of samples were calculated by Argentometric method (APHA, 2012). Nitrates were estimated by absorbance method (APHA 2016) and Phosphates were calculated by Stannous Chloride method (APHA, 2005). Heavy metals were analysed by Atomic Absorption Spectroscopy method (APHA, 2005).

RESULTS AND DISCUSSIONS

The domestic wastewater effluents from rural and urban areas contain a number of toxic elements which includes organic and inorganic components and heavy metals. As per CPCB guidelines (2008c), the pH of wastewater would be remaining between 6 and 8.5 for agricultural reuse. The change of pH within CWPK was 7.75±0.01 to 7.4±0.04 in 2018 and 7.68±0.02 to 7.37±0.05 in 2019 from January to June. There was a slight reduction of pH value in last two months within planted wetland. Almost similar results were showed by *Phragmites mauritianus* and *Typha latifolia* in SSCW in a time period of Feb. to May 2003 at Tanzania (Kaseva, 2003). Raju *et al.,* 2010 treated DWW in Imhoff tank planted with floating weed *Lemna minor* and they observed the change in pH as 7.67 to 7.60 which were different to our results and reduction percentage of EC as 34.4% which suggested that the said treatment plant is not efficient in comparison to our treatment plant.

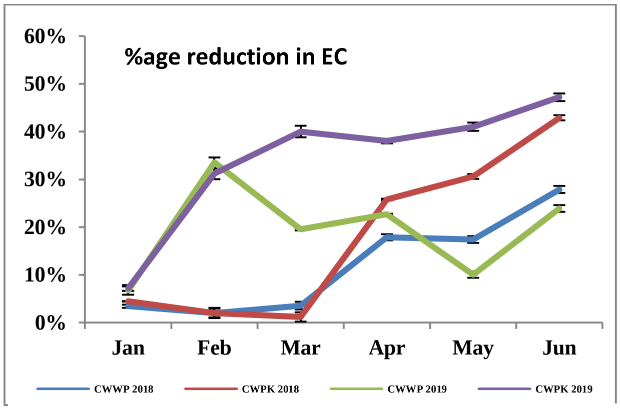

Fig. 5: Variation of EC in wetlands in comparison to DWW

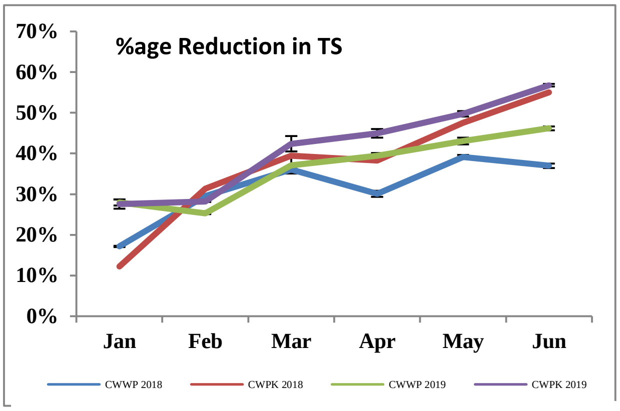

Fig. 6: Variation of TS in wetlands in comparison to DWW.

The EC of domestic wastewater were ranged from 1320.67±8.84 (µS/cm) (Apr) to 1419±6.81µS/cm (Jan) in 2018 and 1313.20±6.36 µS/cm (Apr) to 1594.67±9.02 µS/cm (Mar) in 2019 (Table-1) The observed EC was totally different from the treatment wetland plant planted with *Hydrilla verticillata* and by comparing these two plants the experimental plant vetiver is more efficient with respect to the reduction of EC. The reduction contribution of *P. karka* was increased from nothing in 1st month to 14.02% at 6th month in 2018 and there was not too much variation in 2019 when compared with CWWP. The total solid present in water simply refers the matter either filterable or non-filterable that remains as residue upon evaporation and subsequent drying at a defined temperature. The concentrations of TS in domestic wastewater were ranged from 2963±35.51 (Apr) to 3358.33±43.43 (Mar) in 2018 and 3178.67±18.70 (May) to 3765±31.75 (Mar) in 2019 (Table 1). The reduction percentage of TS by CWPK was within a range of 12.24±0.55 (Jan) to 55.03±1.15 (Jun) in 2018 and 27.58±1.13 to 56.77±0.31 in 2019 (Fig. 6). Root zone treatment technology reduces 69% TS from SWW (Varne and Wagh, 2014). The ASHFCW planted with *E. crassipes, T. latifolia, C. esculenta, C. indica, P. maximum* and *P. purpureium* showed removal efficiencies of TS during summer season as 36.34%, 34%, 33.33%, 36.79%, 37.01%, and 37.85% (Dhulap *et al.,* 2014). The contribution of *P. karka* for the reduction of TS was increased from 1.85±0.17% to 18.05±0.65% in 2018 and 2.96±0-.29% to 10.59±0.57% in 2019 when taken CWWP in comparison.

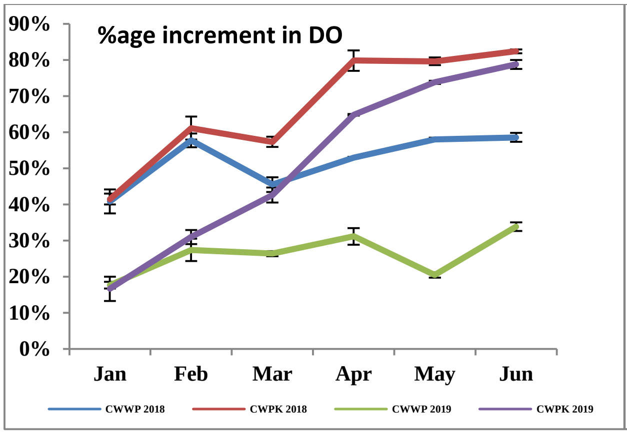

Fig.7: Variation of DO in wetlands in comparison to DWW.

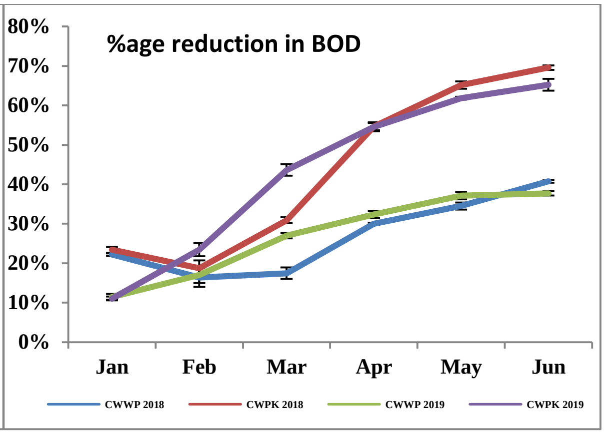

Fig. 8: Variation of BOD in wetlands in comparison to DWW.

The concentration of DO is necessary in water as many forms of life use dissolved oxygen for their respiration. The analyzed results had shown that DO in DWW were ranged from 0.52±0.03mgL^{-1} (Feb) to 0.77±0.02 mgL^{-1} (May) in 2018 and 0.75±0.04 mgL^{-1} (Jun) to 0.87±0.03 mgL^{-1} (May) in 2019 (Table 2). The percentage increment showed by CWPK was within a range of 41.48±2.35 to 82.42±0.97 in 2018 and 16.63±1.25 to 78.77±0.88 in 2019 (Fig. 7). The SSCW planted with *Phragmites mauritianus* and *Typha latifolia* showed DO percentage increment rate as 54.44% and 51.11% within a time period of Feb. to May in 2003 at Tanzania (Kaseva, 2004) whereas *Salvania molesta* showed similar results in same type of treatment technology (Acenas *et al.,* 2012). The percentage increment in DO increased during the last months in 2018 and 2019 indicated aerobic conditions in wetlands due to effective transfer of O_2 through the rhizosphere of plant. The contribution of plant was increased from0.65±1.08% at 1st month to 23.85±0.38% at 6th month in 2018 and 3.58±1.27% at 2nd month to 44.95±1.35% at 6thmonth in 2019 when took CWWP in comparison. The BOD measures the O_2 demand of biodegradable pollutants calculated data had shown that the BOD of DWW ranged from 297.30±3.72 mgL^{-1} (Jun) to 356.94±6.93 mgL^{1} (Jan) in 2018 and 296.84±5.63mgL^{-1} (Jun) to 375.03±5.27mgL^{-1} (Jan) in 2019 (Table-1). Almost similar results were analysed by Sonune *et. al.,* 2015 while studying domestic wastewater in Vishnupuri. The reduction percentage in BOD shown by CWPK was 18.71±2.04 (Feb) to 69.58±0.56 (Jun) in 2018 and 11.07±0.46 (Jan) to 65.23±1.5 (Jun) in 2019 (Fig. 8). The PSCW planted with *P. australis* showed better efficiency for the reduction of BOD (75.99%) (Sudarsan *et al.,* 2015). The removal efficiency of BOD are lower than the results reported by Zurita *et al.* (2009) who found 78.2% removal of BOD by HSSFCW planted *Zantedeschia aethiopica.* The contribution of plant for BOD was increased from 2.32±0.61% at 2nd month to 23.85±0.21 at 6th month in 2018 and 6.44±0.54% at 2nd month to 27.51±1.03% at 6th month in 2019.

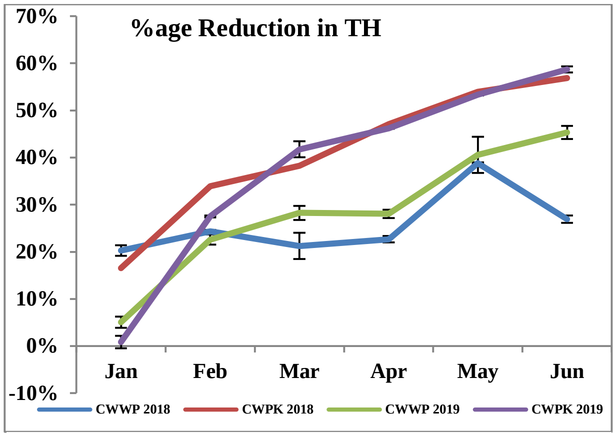

Fig. 9: Variation of TH in wetlands in comparison to DWW.

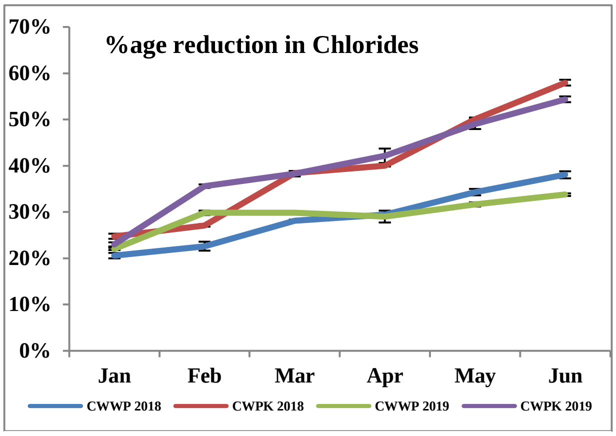

Fig. 10: Variation of Cl^- in wetlands in comparison to DWW.

Total hardness is characteristic of water which represents the total concentration of calcium and magnesium ions present in water The analysed data had shown that total hardness of DWW ranged from 715.5±6.12mgL^{-1} (Jun) to 825.5±7.76mgL^{-1}(May) in 2018 and 696.33±3.84mgL^{-1} (Jun) to 818.67±7.45mgL^{-1} (Feb) in 2019 (Table 1). The percentage reduction for TH was 16.52±0.19 to 56.4±1.12 in 2018 and 10.86±1.35 to 58.69±0.63 in 2019 (Fig. 9). Raju et al, 2010 treated DWW in Imhoff tank planted with floating weed *Lemna minor* and reduction percentage of TH was 13.64%which suggested that the said treatment plant is not efficient in comparison to our treatment plant. The significant rate of reduction was observed within the experimental set up planted with *P. karka* but in comparison to *Typha angustata* and *Phragmites australis* the plant is not too much efficient (Patel and Dharaiya, 2014). *Phragmites australis* and *Typha angustata* planted in VFCW gave 70% and 75.84% reduction in TH from Diary effluent with 7 HRT. The contributions of *P. karka* were increased from 9.58±2.98%at 2nd month to 29.96±0.31% at 6th month in 2018 and 3.9±0.32% at 2nd month to 13.36±1.39% at 6th month in 2019. Presence of Chlorides in domestic waste water is one of the main characteristics for the dissolution of salt deposits released from households. The analysed data had shown the concentration of Cl^- as 159.21±2.76mgL^{-1} (Apr) to 181.67±5.54mgL^{-1} (Jun) in 2018 and 159.77±2.23mgL^{-1} (Apr) to 180.64±1.83mgL^{-1} (Feb) in 2019 (Table 1). The reduction percentage of Chlorides by CWPK was 24.76±0.56 (Jan) to 57.97±0.65 (Jun) in 2018 and 23.01± 0.46 (Jan) to 54.38±0.62 (Jun) in 2019 (Fig. 10). Imhoff tank planted with *Lemna minor* reduced 14.28% Cl^- from DWW and was not efficient to our treatment set up (Raju *et al.,* 2010). *Phragmites australis* (67.50%) and *Typha angustata* (88.4%) planted in VFCW gave better results whereas *Parthenium* plant mass removed 30% – 35 %from DWW which is very less compared to treatment setup. The untreated discharge of sewage and domestic waste acts as the main sources of nitrates and phosphates for the ground water pollution and is significantly needed for the functioning of terrestrial as well as aquatic ecosystem. The analysed concentration of NO_3-N in DWW were ranged from 38.59±1.19 (Feb) to 46.12±0.95 (Apr) in 2018 and 40.99±1.37 (Jun) to 47.56±1.09 (Apr) in 2019 and PO_4^{3-} as 10.54±0.22 (Jan) to 12.56±0.59 (Jun) in 2018 and 10.99±0.28 (Feb) to 12.34±0.25 (Apr) in 2019 (Table-1).

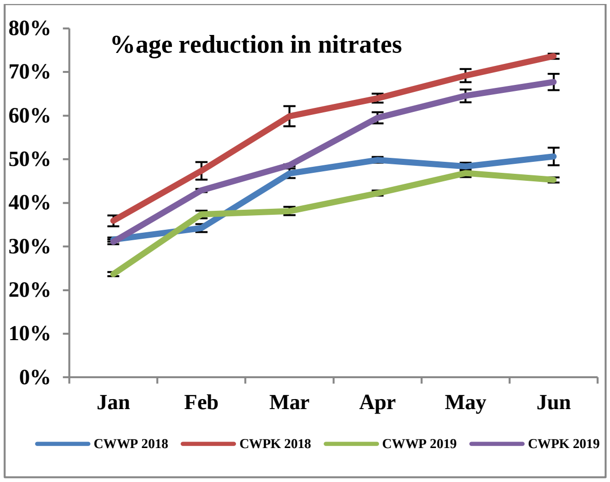

Fig. 11: Variation of NO_3^- in wetlands in comparison to DWW.

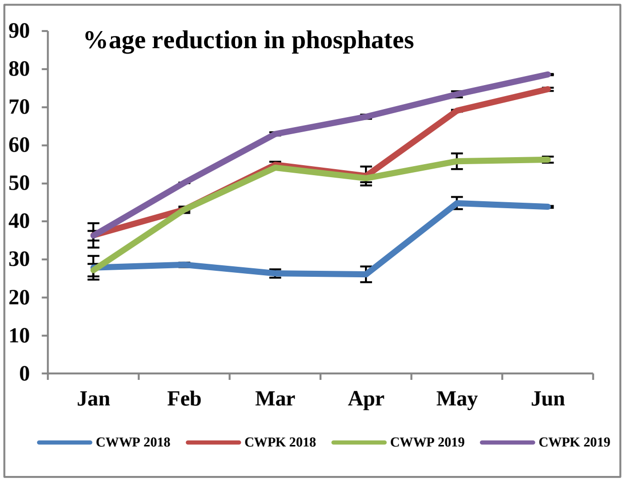

Fig. 12: Variation of PO_4^{3-} in wetlands in comparison to DWW.

The NO_3-N and PO_4^{3-} of MWW in Kuwait was higher than our calculated results and the concentration were ranged from 44–100 mgL^{-1} and 14–64mgL^{-1} (Enezi *et al.,* 2013). Similar results were observed by Sonune, et al., 2015 while studying domestic wastewater in Vishnupuri. The reduction percentage was 35.87±1.26 (Jan) to 73.42±0.59 (Jun) in 2018 and 31.09±0.54 (Jan) to 67.71±1.85 (Jun) in 2019 for NO_3-N and 36.32±1.23 (Jan) to 74.74±0.43 (Jun) in 2018 and 36.24±1.25 (Jan) to 78.61±0.15 (Jun) in 2019 for PO_4^{3-} (Fig.11&12). Treatment setups planted with *T. latifolia* and *P. australis* showed 60.24% and 58.64% reduction for NO_3-N and 61.48% and 51.16% for PO_4^{3-}(Hussain *et al.,* 2014) which were not as efficient to our calculated results. The contribution of plant for reduction was increased from 4.25±0.78% at 1st month to 22.98±1.47% and 28±0.74% at 6th month in 2018 and 5.51±0.52% at 2nd month to 22.44±2.30% at 6th month in 2019 for NO_3-N. Similarly, the reduction for PO_4^{3-} was 8.5±0.83% at 1st month to 30.93±0.65% at 6th month in 2018 and 7.07±0.32% to 23.34±0.78% in 2019 as taken CWWP in comparison. The results had suggested that the phosphate concentration reduction occurs on highest level when the plants forms it vast root zone area. Enhanced Chemical Coagulation showed 66% reduction of TP from DWW which is less than planted constructed wetland after 6 months of treatment (Sarparastzadeh, 2005).

The heavy metals readily accumulate either in soil and organisms upto toxic levels. So long term application of heavy metals on land in any form results in the elevated levels of heavy metals in soil. The concentration of Fe in DWW were ranged from 2.54±0.04 (Apr) to 3.18±0.01 (Feb) in 2018 and 2.45±0.01 (May) to 2.92±0.05 (Feb) in 2019 (May), concentration of Zn were ranged 72.67±1.20 (Jun) to 87.77±2.39 (May) in 2018 and 70.73±1.2 (May) to 88.33±0.58 (Feb) in 2019 (May) (Table-1). The concentration of Zn in DWW at Titagarh West Bengal was ranged from 0.21 mgL^{-1} to 4.3mgL^{-1} and after treatment the concentration was 0.1mgL^{-1} to 3.9mgL^{-1} for Zn (Gupta et al, 2008). The reduction percentage shown by CWPK for Fe were within a range of 17.81±0.94 (Jan) to 57.52±0.8 (Jun) in 2018 and 10.12±0.95 (Jan) to 57±0.47 (Jun) in 2019, Zn as 30.94±0.68 (Jan) to 82.88±0.21 (Jun) in 2018 and 21.5±1.3 (Jan) to 76.33±0.77 (Jun) in 2019 (Fig 13 & 14). Hussain *et al.,* (2014) reported the removal rates for heavy metals from DWW treated in CW planted with *T. latifolia* and *P. australis* and calculated results were 33.04% and

27.76% for Fe; 36.21% and 37.31 for Zn; 88.22% and 83.66% for Cu. The contribution of *P. karka* were increased from 0.50±0.57%at 1st month to 21.18±0.5%at 6th month in 2018 for Fe, 7.69±0.95% and 3.42±1.27% at 1st month to 48.82±0.65% and 51.86±1.61% at 6th month in 2018 for Zn when compared with CWWP. Similarly, during 2019, the contribution of *P. karka* was increased from 2.37±0.14% at 2nd month to 15.52±0.11% at 6th month for Fe, 17.28±0.63% at 2nd month to 38.67±0.93% at 6th month for Zn.

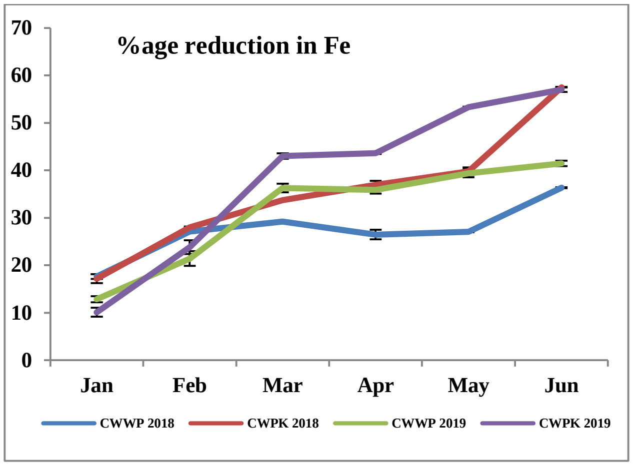

Fig. 13: Variation of Fe in wetlands in comparison to DWW.

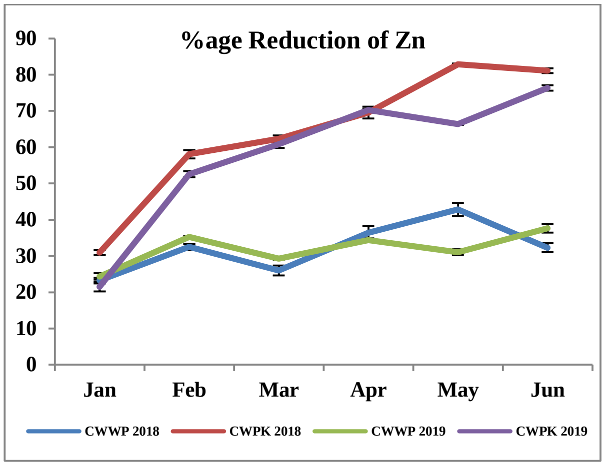

Fig. 14: Variation of Zn in wetlands in comparison to DWW.

CONCLUSION

Wastewater produced from Mahalgaon residence meets the reference values of Domestic wastewater (sources). Two year round experimental study had concluded that there was a minor change in pH and the EC doesn't lower too much. The nitrification/denitrification processes as well aerobic decomposition of organic matter were increased. Constructed wetland planted with *P. karka* ensures the removal of total solids, total hardness, Chlorides, nitrates, phosphates and BOD_5. The DO of the wetland in presence of plant were increased too much in comparison to wetland without plants. The management and design of substrate profile are of great of importance for the contribution towards an efficient and sustainable performance of treatment plant. The application of wetlands for treatment of contaminated water will make people of Gwalior able to dispose of their wastes hygienically and efficiently. Comparatively during 2019, the said treatment showed best performance. The treated water could be utilized for industrial processes, household activities, and irrigation purposes.

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Table-1: Percentage Reduction of Physiochemical parameter in CWWP and CWPK comparatively.

	C. Wetland	Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.
EC	CWWP	2018	3.44±0.87	2.03±1.07	3.55±0.23	17.89±0.9	17.39±0.69	27.90±-0.71
		2019	6.75±0.36	33.55±0.94	19.56±0.81	22.74±0.81	10.06±0.71	23.91±0.74
	CWPK	2018	4.49±0.4	2.03±1.07	1.21±0.99	25.79±1.6	30.60±0.51	42.89±0.54
		2019	7.25±0.61	31.19±1.15	40.02±1.19	38.02±0.44	41.01±0.87	47.20±0.79
T. Solids	CWWP	2018	17.15±0.16	29.52±0.47	36.02±0.25	30.10±0.75	39.16±0.44	36.99±0.55
		2019	12.24±0.55	31.37±0.29	39.40±2.1	38.30±1.8	47.58±0.42	55.03±1.15
	CWPK	2018	27.97±0.73	25.27±0.17	37.07±2.01	39.43±0.7	43.07±0.81	46.18±0.46
		2019	27.58±1.13	28.22±1.07	42.37±1.86	44.93±1.06	49.71±0.66	56.77±0.31
BOD	CWWP	2018	22.19±0.30	16.4±2.43	17.44±1.46	29.96±1.28	34.50±0.91	40.73±0.36
		2019	11.47±0.65	17±1.18	26.99±0.77	32.32±0.8	37.14±0.72	37.72±1.96
	CWPK	2018	23.39±0.72	18.71±2.04	30.91±0.72	54.62±0.93	65.11±0.93	69.58±0.56
		2019	11.07±0.46	23.45±1.67	43.67±1.46	54.57±1.14	61.82±0.35	65.23±1.5
TH	CWWP	2018	20.27±1.19	24.33±1.09	21.23±1.48	22.67±0.88	28.82±3.82	26.94±1.82
		2019	5.08±1.11	22.60±0.33	28.27±1.07	28.06±0.66	40.58±0.19	45.33±0.76
	CWPK	2018	16.52±0.19	33.92±1.89	38.25±0.81	47.10±0.14	53.94±0.42	56.4±1.12
		2019	10.86±1.35	27.53±0.21	41.75±1.7	46.19±1.7	53.34±1.16	58.69±0.63
Cl^-	CWWP	2018	20.59±0.59	22.62±0.95	28.10±0.26	29.41±0.22	34.29±0.69	38.07±0.76
		2019	22.05±0.23	29.82±0.46	29.85±1.08	29.02±1.28	31.65±0.45	33.77±0.26
	CWPK	2018	24.76±0.56	27.12±0.27	38.41±0.49	40±0.16	50.08±0.33	57.97±0.65
		2019	23.01±0.46	35.61±0.37	38.31±0.58	42.2±1.05	49.04±1.11	54.38±0.62
NO_3^-	CWWP	2018	31.61±0.48	34.20±0.92	46.78±1.08	49.86±0.65	48.35±0.89	50.64±2.01
		2019	23.68±0.49	37.34±0.87	38.31±0.93	42.43±0.57	46.8±0.93	45.27±0.57
	CWPK	2018	35.87±1.26	47.32±1.99	59.88±2.32	63.99±1.03	69.19±1.5	73.42±0.59
		2019	31.09±0.54	42.85±0.36	48.65±0.23	59.51±1.26	64.54±1.49	67.71±1.85
PO_4^{3-}	CWWP	2018	27.82±1.13	28.59±0.57	26.32±0.57	26.07±1.09	44.82±1.07	43.81±0.28
		2019	27.18±1.03	43.06±0.37	54.12±0.43	51.37±1.08	55.84±2.07	56.26±0.8
	CWPK	2018	36.32±1.23	43.07±1.06	54.87±0.81	51.84±1.45	69.08±0.25	74.74±0.43
		2019	36.24±1.25	50.14±0.7	63.01±0.45	67.49±0.55	73.38±0.81	78.61±0.15
Fe	CWWP	2018	17.63±0.53	27.14±0.32	29.20±0.67	26.48±1.03	27.04±1.07	36.35±1.04
		2019	12.87±0.66	21.43±1.57	36.26±0.89	35.90±0.8	39.40±0.84	41.48±0.59
	CWPK	2018	17.81±0.94	27.98±0.17	33.75±1.01	36.98±0.8	39.8±0.80	57.52±0.8
		2019	10.12±0.95	23.81±1.45	43.02±0.58	43.65±1.09	53.30±0.14	57±0.47
Zn	CWWP	2018	23.25±0.79	32.48±0.84	26.02±1.37	36.38±1.03	42.83±1.08	32.28±1.24
		2019	24.34±0.89	35.29±0.21	29.22±0.29	34.35±0.49	31.04±0.78	37.66±1.19
	CWPK	2018	30.94±0.68	58.05±1.14	62.32±0.98	69.56±1.03	82.88±0.21	81.1±0.65
		2019	21.50±1.30	52.57±0.84	60.84±1.01	70.25±0.37	66.41±0.28	76.33±0.77

Table-2: Percentage increment of DO in CWWP and CWPK comparatively.

DO	CWWP	2018	40.83±1.36	57.73±1.93	2.04±2.04	52.93±1.24	58.01±0.44	58.57±1.25
		2019	41.48±2.35	61.13±1.87	57.31±1.49	79.83±1.02	79.64±1.16	82.42±0.97
	CWPK	2018	17.61±0.92	27.38±1.11	26.37±0.69	31.16±1.31	20.45±0.77	33.82±1.18
		2019	16.63±1.25	30.96±1.14	42.6±0.35	64.82±1.08	73.38±0.56	78.77±0.88