Biolife 2(1):297-305

eISSN (online): 2320-4257
www.biolifejournals.com/home.html

BIOLIFE ORIGINAL ARTICLE

DETERMINATION OF WATER QUALITY INDEX OF SEWAGE WATER FOR QUICK ASSESSMENT OF BIOMONITORING AND BIOREMEDIATION

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ABSTRACT

Champa Devi site of Ramgarh Lake is being polluted day by day due to heavy sewage discharge of colonies situated at the catchment of this lake. Its water used in drinking purpuses by the cattles and in ground water recharging. Therefore, an attempt has been made to treat sewage water with a low cost biotreatment method and assess the bioremediation by determining the WQI of biotreated sewage water. The WQI is helpful in quick assessment of bioremediation and biomonitoring of biotreated sewage water. The sewage water after biotreatment undergo bioremediation process so the WQI gradually tending towards its betterment with the increase in biotreatment period. This is due to the uptake of pollutants by the flora (Eichorrnia sp.). Toxicants present in the sewage water hits the AChE activity in the nervous tissues of L. acuminata due to which the enzyme activity reduces upto 8.28%. After biotreatment of sewage water there was gradual down in pollution load hence gradual improvement in WQI from 232.11 to 115.51 and in AChE activity from 0.070 to 0.143 µ mol ´SH´ hydrolysed/min/mg protein (17.94%). Thus WQI is helpful and useful tool for the quick assessment of bioremediation of biotreated sewage water.

Key words : Biotreatment, AChE, WQI, Bioremediation, Biomonitoring.

INTRODUCTION

In the absence of any treatment plant, sewage water of colonies situated at the catchment of water body is directly poured and causes a deadly problem to inhabiting organism health. Lakes are one of the important water resources used for irrigation, drinking, fisheries and flood control purposes (kumar et al. 2006). It is necessary to treat the sewage discharge by any of the low cost means. In this study flora and fauna are used for biotreatment and biomonitoring of sewage water. Biological treatments are considered as one of the safer, cleaner, cost effective and eco friendly technology (Lofrano et al., 2013) for decontaminating the sites which are going to be contaminated by direct discharge of untreated sewage into fresh water bodies. Various industrial and anthropogenic activities resulted in increased contaminated sites due to unawareness regarding production, use and disposal of hazardous substances (Srinivas et al., 2013). The process of biotreatment by using various agents such as bacteria (Lofrano et al., 2013), yeast, fungi, algae (Samsuddoha et al. 2006) and higher plants acts as major tools in treating polluted environment. A continuous search for the new biological forms is required to regulate increasing pollution and environmental problems faced by man residing in an area (Bhatnagar and Kumari 2013). Macrophytes play important roles in balancing the lake ecosystem. They have capacity to improve the water pollution level with their effective and massive root system involving in uptake of pollutants (*Dhote and Dixit 2007*). Eichorrnia sp. is well known for the sewage waste treatment (Jamuna and Noorjahan, 2009). The fresh water snails are found in abundance in water streams and ponds almost throughout the year with the exception of small period of dormancy in winter and spring (Singh *et al*., 2012).

AChE activity in snails acts as a sensitive bioindicator for biomonitoring the pollution in different water bodies (Singh et al., 2011). It is one of the versatile enzyme of nervous system, playing a role in neurotransmission (*Tripathi and Srivastava 2008*) also found in snail *L. acuminata* which is used as environmental biomarker in number of studies (*Singh and Singh 2009*). *E. crassipes* is well known for the removal of heavy metals like *Zn, Co, Cd, Cu, Pb, Hg* (*Erzsebet et al., 2011*). The *E. crassipes* is considered in this research work due to their high metal removal rates of close to 100% have been reported in both *in vitro* and *in vivo* conditions (Matagi *et al.*1998). In this study both flora and fauna are used for ex-situ biotreatment and biomonitoring of sewage water from collected site. Further computation of WQI of biotreated and biomonitered sewage water had been done to judge the remediation extent of biotreatment sewage water. The WQI was first developed by Horton in the early 1970s. It is very useful technique for quick assessment of any water system (Mukherjee et al., 2012). It provides a single number that expresses overall water quality at a certain location and time, based on several water quality parameters. The objective of Water Quality Index is to turn complex water quality data into information that is understandable and used by the public. A single number cannot tell the whole story of water quality parameters that are not included in the index.

However, a Water Quality Index based on some very important parameters can provide a single indicator of water quality (Sinha 1995, Naik and Purohit 1996). In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a lake with number (Vaisnav and Sahu 2006).The WQI was calculated by using the standards of drinking water quality recommended by the World Health Organisation (WHO), Bureau of Indian Standards (BIS) and Indian Council for Medical Research (ICMR).

MATERIAL AND METHODS

Study Area:

District Gorakhpur is situated in the north-east “Tarai” region of U.P. (India) and lies between 26.5º-27.9º N and 83.4º- 84.26º E at an altitude of 95 metre above sea level. It is a shallow, perennial eutrophic lake situated at 26º 44' 9" N, and 83º 24' 16" E eastern side of the Gorakhpur town. It covers an area of about 15 km^2 during summer and 22 km2 in the monsoon period. In this study, for the determination of WQI in sewage water, site (Champa Devi) of Ramgarh lake was selected.

Experimental set up:

An ex situ setup was made to see the ecological role and efficiency of flora and fauna in the biomonitoring and biotreatment of sewage water. Polluted water is collected and both flora and fauna was cultured in polluted water. In polluted water the culture had been done in six aquarium in which *Eichorrnia sp.* + *L.acuminata* were taken. Young aquatic plants collected in plastic bags cleaned and rinsed with double distilled water and 500 gms of average size plants (25 cm) were taken in six replicates of *Eichorrnia sp.* + *L.acuminata* in aquarium. Experimental snails (*L. acuminata*, length 2.3±.25 cm) collected in plastic bags from low lying submerged areas and cultured in tap water under lab condition, polluted water in 20 litre gallons from Champa devi and poured in each replicates (aquarium) containing six litre water.

Enzyme assay:

1. Measurment of AChE activity:

Pollution level is determined by measuring the AChE (*Acetylcholinesterase*) activity in snail nervous tissues by Ellman et al., (1961) modified by Singh and Agarwal (1983). Nervous tissue of 20 experimental snails (50mg) was dissected out arround the buccal mass and homogenized into 1ml of .1M phosphate buffer, p^H 8, for 5 minutes in each ice bath and centrifused at 1000 g or 1350 rpm for 30 minutes at 4^0c.The supernatent was used as enzyme source. The enzyme activity was measured by using incubation mixture consisting of 0.05ml of enzyme source, 1.45ml of 0.1M phosphate buffer (pH 8), 0.05ml of choromogenic agent DTNB reagent and .1ml freshly prepared Acetylthiocholine iodide (ATChI) solution in distilled water. The absorbance changed in optical density at 412 nm was continuously recorded till 18 minute after every 3 minute interval. Enzyme Activity was expressed as µ mol ´SH´ hydrolysed/min/mg protein.

2. Protein:

Protein in the enzyme source was estimated by the method of Lowry et al., (1951).

Water quality assessments:

Water qualities variables are determined by the water sample collected at regular intervals from culture water of aquarium and were analysed by APHA (2005). Instrumental analysis was done for analyzing the physical parameters like P^H, EC., TDS., Total alkalinity, TH., DO, BOD and Ca++ values by flame photometers, Mg++ values was determined by using prescribed formula.

Determination of Water Quality Index (WQI) of Culture Water:

In this study, for the calculation of water quality index, thirteen important parameters were chosen. The WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organisation (WHO), Indian council of Medical Research (ICMR) and Bureau of Indian Standards (BIS) has been used for the calculation of WQI of the water body. Further, quality rating or sub index (*qn*) was calculated using the following expression.

$$qn = 100\,(Vn - Vio) / (Sn - Vio)$$

(Let there be *n* water quality parameters and quality rating or sub index *(qn)* corresponding to *nth* parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value).

qn = Quality rating for the n^{th} Water Quality parameter

Vn = Estimated value of the n^{th} parameter at a given sample station.

Sn = Standard permissible value of the n^{th} parameter

Vio = Ideal value of n^{th} parameter in pure water *(i.e, 0 for all other parameters except the parameters* P^H *and Dissolved oxygen 7.0 and 14.6mg/l respectively)*.

Unit weight was calculated by a value inversely proportional to the recommended standard value *Sn* of the corresponding parameter.

Wn = K/Sn

Wn = unit weight for nth parameters

Sn = Standard value for n*th* parameters

K = Constant for proportionality

Thus, the overall Water Quality Index was calculated by aggregating the quality rating with the unit weight into following formula:

$$WQI = \sum qn * Wn / \sum Wn$$

RESULTS AND DISCUSSION

All the parameters except pH, Total hardness and BOD are within the permissible limit recommended by BIS/ICMR (1993, 1975) and WHO (1992) (Table-2). Parameters such as pH, Dissolved oxygen (DO), Biochemical Oxygen Demand (BOD) have been considered as the important water quality parameters for classification of surface water (Table-2) (Yogendra and Puttaiach, 2008, Samantray et al., 2009). The sewage water was cultured with flora (Eichorrnia) and Fauna (Snail, *L. acuminata*) till four months.

The WQI of sewage water biotreated with Eichorrnia sp. and biomonitered with snail *L. acuminate* was computed by considering nine parameters given in Table (3, 4, 5, 6, 7, 8) respectively of 0 day control water, 0 day sewage water, 1, 2, 3 and 4 month of biotreated sewage water. AChE activity in snails which was kept in biotreated sewage water culture was computed also in every month with respect to control water. The WQI of control water was noted 43.89 and rated as good quality water (Chatterji, and Raziuddin et. al., 2000) but the WQI of polluted water of 0 day is 232.11 showing unsuitable for drinking range (Chatterji, and Raziuddin et. al., 2000).

Table1: Water Quality Status and Index level (WQI) of water quality (Chatterji, and Raziuddin et. al., 2000)

Water quality status	Water quality Index Level
Excellent water Quality	0-25
Good water Quality	26-50
Poor water Qualty	51-75
Very poor water Quality	76-100
Unsuitable for drinking	>100

This study deals with the biotreatment of sewage water with flora and fauna. The Water Quality Index of biotreated sewage water of four months ranging from 171.79-115.5 showing an improvement tendency in WQI therefore, gradual improvement in water quality (Chatterji and Raziuddin et. al., 2000). This was shown below in graph (Figure: **1**).

The WQI value up to 300 of an industrial area was obtained by Shankar and Sanjeev (2008) while Khan (2011) had WQI value up to 142. Bioremediation, both in situ and ex situ have also strong scientific growth due to the increased use of natural attenuation (Kumar et al. 2011).

The AChE activity in snails in control water is 0.797 µ mol ´SH´ hydrolyzed/min/mg protein which was assumed as 100% for this study and AChE activity of 0 day untreated sewage water is 0.066 µ mol ´SH´ hydrolyzed/min/mg protein showing only 8.28% with respect to control water. The AChE activity in the snails in biotreated water till four month ranging from 0.07-0.143 (µ mol ´SH´ hydrolyzed/min/mg protein showing percent increment range 8.78 - 17.94% with respect to control water indicating that water quality tending towards remediation. This was shown in graph (Figure: **2**).

It is also clear from the result section that AChE activity acts as a sensitive bioindicator for biomonitoring the pollution in different water bodies (Singh et al., 2011). Toxicants present in the water hits the AChE activity in the nervous tissues of L. acuminata. In the present study when there is a monthly bioremediation of polluted water by flora, there is a significant recovery in AChE activity in snails brain. It clearly indicates that in polluted water bodies, there is a stress of pollutants on the activity of AChE due to which its activity was decreased upto 0.066 µ mol ´SH´

Table-2: Drinking Water standards by recommending Agencies and unit weights (All values except pH and Electrical Conductivity are in mg/L).

S. No.	Parameters	Standard Units	Recommended Agency(1975, 1993)	Unit Weight
1	pH	6.5 – 8.5	- ICMR / BIS	0.2190
2	Dissolved oxygen	300 mg/lit	ICMR	0.0037
3	Electrical Conductivity	500 milli moles	ICMR / BIS	0.0037
4	Total Dissolved Solids	500 mg/lit	ICMR / BIS	0.0155
5	Total Alkalinity	300 mg/lit	ICMR / BIS	0.0062
6	Total hardness	300 mg/lit	WHO (1992)	0.0037
7	Calcium	30 mg/lit	ICMR / BIS	0.061
8	Magnesium	250 mg/lit	ICMR	0.0074
9	Biological oxygen demand	5.00 mg/lit	ICMR	0.3723

WQI= 43.89; AChE activity in snails =0.797 µ mol ´SH´ hydrolysed/min/mg protein

Table-3: WQI and AChE activity in snails in 0 day untreated sewage water sample.

Parameters	PW (Observed value)	Standard value(Sn)	unit weight (Wn)	qn (Quality rating)	Wn*qn
pH	11	8.5	0.219	266.6667	58.4
EC	51.8	300	0.371	17.26667	6.405933
TDS	490.2	500	0.0037	98.04	0.362748
T.Alkalinity	86.6	120	0.0155	72.16667	1.118583
TH	599	300	0.0062	199.6667	1.237933
Ca++	25.3	75	0.025	33.73333	0.843333
Mg++	160.2	30	0.061	534	32.574
DO	1.7	5	0.3723	134.375	50.02781
BOD	24.8	5	0.3723	496	184.6608
			∑Wn=1.446		∑Wn*qn=335.6311

WQI=232.11; AChE activity in snails =0.098 µ mol ´SH´ hydrolysed/min/mg protein

Table-4: WQI and AChE activity in snails of bioremediated sewage water till one month.

Parameters	PW(Observed value)	Standard value(Sn)	unit weight(Wn)	qn (Quality rating)	Wn*qn
pH	9.1	8.5	0.219	140	30.66
EC	46.9	300	0.371	107.0588	39.71882
TDS	466.3	500	0.0037	15.63333	0.057843
T. Alkalinity	139.8	120	0.0155	93.26	1.44553
TH	339.2	300	0.0062	116.5	0.7223
Ca++	124.2	75	0.025	113.0667	2.826667
Mg++	276	30	0.061	165.6	10.1016
DO	1.4	5	0.3723	137.5	51.19125
BOD	15	5	0.3723	300	111.69
			∑Wn=1.446		∑Wn*Qn=248.414

WQI=171.79; AChE activity in snails =0.070 µ mol ´SH´ hydrolysed/min/mg protein

Table-5: WQI and AChE activity in snails kept in bioremediated sewage water till two month.

Parameters	PW(Observed value)	Standard value	unit weight(Wn)	qn (Quality rating)	wn*qn
pH	9	8.5	0.219	0.219	29.2
EC	43.5	300	0.371	0.371	5.3795
TDS	340	500	0.0037	0.0037	0.2516
T. Alkalinity	28.5	120	0.0155	0.0155	0.368125
TH	239.5	300	0.0062	0.0062	0.494967
Ca++	17.7	75	0.025	0.025	0.59
Mg++	223.8	30	0.061	0.061	45.506
DO	2.2	5	0.3723	0.3723	48.08875
BOD	14.3	5	0.3723	0.3723	136.2618
			∑Wn=1.446	1.446	∑Wn*Qn=236.35

WQI= 163.45

AChE activity in snails =0.066 µ mol ´SH´ hydrolysed/min/mg protein.

Table-6: WQI and AChE activity in snails kept in bioremediated sewage water till three month.

Parameters	PW(Observed value)	Standard value	unit weight(Wn)	qn (Quality rating)	wn*qn
pH	8.9	8.5	126.6667	126.6667	27.74
EC	35.7	300	11.9	11.9	4.4149
TDS	326.3	500	65.26	65.26	0.241462
T.Alkalinity	30.4	120	25.33333	25.33333	0.392667
TH	214.79	300	71.59667	71.59667	0.443899
Ca++	121.3	75	161.7333	161.7333	4.043333
Mg++	93.4	30	311.3333	311.3333	18.99133
DO	3	5	120.8333	120.8333	44.98625
BOD	12.5	5	250	250	93.075
			∑Wn=126.666		∑Wn*Qn=194.3288

WQI= 134.39; AChE activity in snails =0.075 µ mol ´SH´ hydrolysed/min/mg protein

Table7: WQI and AChE activity in snails kept in bioremediated sewage water till four month.

Parameters	PW(Observed value)	Standard value(Sn)	unit weight(Wn)	qn (Quality rating)	Wn*qn
pH	8.8	8.5	0.219	120	26.28
EC	31.5	300	0.371	10.5	3.8955
TDS	314.8	500	0.0037	62.96	0.232952
T.Alkalinity	27	120	0.0155	22.5	0.34875
TH	200.1	300	0.0062	66.7	0.41354
Ca++	23.3	75	0.025	31.06667	0.776667
Mg++	135.8	30	0.061	452.6667	27.61267
DO	3.4	5	0.3723	116.6667	43.435
BOD	8.6	5	0.3723	172	64.0356
			∑Wn=1.446		∑Wn*qn=167.03

WQI= 115.51; AChE activity in snails =0.092 µ mol ´SH´ hydrolysed/min/mg protein

Table-8: WQI and AChE activity in snails Kept in control and sewage water with different exposure periods of biotreatment.

Period	WQI	AChE	% increment in AChE activity in snails.
0 day CW	43.89	0.797	100
0 day PW	232.11	0.066	8.28
1 month	171.79	0.070	8.78
2 month	163.45	0.092	11.54
3 month	134.39	0.111	13.92
4 month	115.51	0.143	17.94

hydrolysed /min/mg protein. After biotreatment there was a bioremediation in sewage water quality and a sharp increase in AChE activity in snails up to 17.94%.

In this research work an effort thus has to be done to pick out a cost effective treatment of waste water by judging the pollution level with the help of active biomonitoring (*ABM*). It involves the translocation of an organism from an unpolluted site to one that is suspected to being polluted and the subsequent analyses of the organism cellular and sub cellular responses, giving an indication of pollutant level in suspected sites (*Smolders et al., 2003*). In this study for active biomonitoring there was collection of organism from unstressed population and their translocation in cages to polluted sites e.g. along a pollution gradient (*Wepener et al., 2005*).

Figure-1. WQI showing gradual decrease in four month

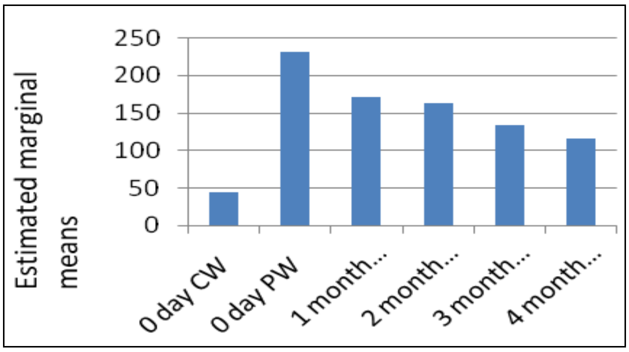
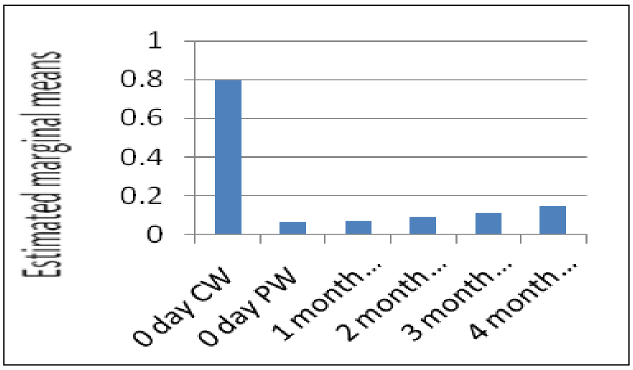


Figure-2. AChE activity µ mol ´SH´ hydrolysed/min/mg protein showing gradual increase in four month



CONCLUSION

The WQI of biotreated and biomonitored water gradually improved with the increase in biotreatment period. This is due to the uptake of pollutants by the flora. Toxicants present in the sewage water hits the AChE activity in the nervous tissues of brain of L. acuminata due to which the enzyme activity reduces upto 8.28%. After biotreatment of sewage water there was gradual down in pollution load hence gradual improvement in WQI upto 115.51 and in AChE activity upto 17.94%. Thus WQI is helpful and useful tool for the quick assessment of bioremediation and biomonitoring of biotreated sewage water.

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DOI:https://dx.doi.org/10.5281/zenodo.7197170
Received: 7 January 2014;
Accepted; 25 February 2014;
Available online : 7 March 2014