A CORRELATION STUDY OF REDUCTION OF TDS IN EFFLUENT USING ALGAL EXTRACTS AND ITS PHYTOCHEMICAL CONSTITUENTS

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ABSTRACT

Industrial waste water treatment has become most emerging area in this era since these pollutants cause toxic effects on human, aquatic animals and also soil. Many methods have been adopted for treating the effluents. This study was carried out to find the efficiency of marine algal extracts on the treatment of leather industry effluent. Generally seaweeds were not effectively used for any purpose but were treated as waste. However, in this study, they were used for treating leather industry effluent effectively. Seaweeds such as *Centeroceras clavulatum*, *Enteromorpha flexuosa*, *Grateloupia lithophila*, *Enteromorpha intestinalis,* and *Ulva lactuca,* were collected from Covelong, Chennai. *Sargassum sp., Amphiroa sp., Ulva sp.,* and *Hypnea sp.* were collected from Kanyakumari and *Chaetomorpha antennina* was collected from Puducherry. Previous work had dealt with seaweeds as adsorbent for wastewater treatment but in the current study, solvent extracts of seaweed were used for the treatment. Seaweeds were soaked in different solvents such as methanol, ethanol, water, chloroform and benzene. The extracts were then used to treat effluent. After treatment, the reduction in TDS was estimated using standard analytical procedures. The results showed that the algal extracts effectively reduced TDS present in the effluent. TDS was highly reduced by EIEC (97 %) and less reduction was found in ACK (25 %). respectively. Among all the solvents, ethanol was found to be the best one followed by benzene, methanol and water.

Keywords: *Effluent, Seaweed, treatment, extract, solvent, TDS.*

INTRODUCTION

Total dissolved solid is the amount of charged ions, including minerals, salts or metals dissolved in a given volume of water. It is expressed as units of mg per unit volume of water (mg/l), also referred to as parts per million (ppm).

An increased TDS concentration is not a health hazard. The TDS concentration is a secondary drinking water standard and for that reason is regulated because it is more of an aesthetic rather than a health hazard. High TDS may affect the quality of water and interferes with washing clothes and also corrodes the plumbing fixtures. In addition to tastiness, certain components of TDS such as chlorides, sulphates, magnesium, calcium and carbonates also affect corrosion [1]. High levels of TDS (above 500 mg/l) result in excessive scaling in water pipes, water heaters, boilers and household appliances such as tea kettles and steam irons [2]. This scaling may reduce the life of these equipments [3].

Aaron Crotts stated that using ammonium hydroxide in the wastewater decreases the level of TDS [4]. After performing the experimentation with varying concentration of ammonium hydroxide, TDS level was estimated. At high ammonium hydroxide, the TDS was found to be lowered by 52.7%, and even at the lowest concentration it was lowered by approximately 6.0%. This treatment method may also have some drawbacks. Unlike the urea compound which is currently being used, the ammonium hydroxide is only found in the form of liquid solution. As a result, vapors which will be produced during the usage of ammonium hydroxide are harmful to human health. This problem could be eliminated if a fume hood or by providing proper ventilation while the ammonium hydroxide is being applied.

An attempt was made to investigate plant materials such as Indian gooseberry bark (*Phyllanthus emblica*), lemon peel (*Citrus limon*), peanut husk (*Arachis hypogaea*) and vetiver root (*Vetiveria zizanoides*) for reducing the TDS in domestic ground (hard) water [5].

Roughing filters were also used to separate fine solids from the water. These mainly acted as physical filters and reduce the solid mass. In this method, large filter surface area available for sedimentation and relatively small filtration rates supports adsorption as well as chemical and biological processes. Therefore, in addition to solid matter separation, roughing filters also improve the bacteriological water quality to a minor extent and also change some other water quality parameters such as color, amount of dissolved organic matter [6].

Krishna Prasad stated that *Lactobacillus* genera are known to be developed into a microbe which has the capacity to reduce TDS because of its probiotic nature [7].

TDS are not noticeably removed by using conventional water treatment processes. The addition of chemicals during conventional water treatment generally increases the TDS concentration [8]. Certain treatment processes, such as sodium exchange zeolite softening and lime-soda ash softening may slightly decrease or increase the TDS. Demineralization processes were also used for the removal of TDS significantly. Though the technology is available to reduce TDS levels, the cost may be a major constraint. Reverse osmosis and electrodialysis would be the most economical processes for reducing TDS [9].

In activated sludge process high elimination of inorganic matters compared with the mechanical stage of the conventional treatment plants was achieved. Without adding alum salt, the removal efficiency of the TDS and the total Iron (Fe) were found to be approximately 28.91 % and 45.07 % respectively. Addition of alum improves the elimination efficiency of TDS and the total Iron in the first treatment stage.

MATERIALS AND METHODS

Collection and Preservation of Seaweed

Marine algae used in this study were collected from coastal regions of Tamil Nadu and Puducherry. Marine algal species such as *Centeroceras clavulatum*, *Enteromorpha flexuosa*, *Grateloupia lithophila* , *Enteromorpha intestinalis, Ulva lactuca.,* and *Chaetomorpha antennina* were collected from Covelong, Chennai. Samples of *Sargassum sp., Amphiroa sp., Ulva sp.,* and *Hypnea sp.* were collected from Kanyakumari whereas *Chaetomorpha antennina* from Puducherry. They were identified by Dr.M.Baluswamy, Professor and Head, Department of Plant biology and Plant Biotechnology, Madras Christian College, Tambaram, Chennai. The collected samples were thoroughly washed with water to remove sand and epiphytes present in it. After complete washing, they were dried under sun light. Then the dried algae were powdered well using a mixer and stored.

Preparation of Algal Extracts

Pre weighed amount of powdered samples were soaked in non polar, polar and water solvents for stipulated time and the phytochemical constituents were extracted. Table.1 shows the various extracts of seaweed and their abbreviations used in this study for convenience.

Collection of Effluent

Leather industry effluent was collected from the canal which was connected to the Peria Eri located at Nagalkeni village, Pallavaram, Chennai, Tamil Nadu and was preserved in a refrigerator to avoid further microbial contamination.

Phytochemical Analysis

Phytochemical constituents such as Terpenoids, Triterpenoids [10], Phenol [11], Flavonoids [12], Tannins [13], Aminoacid [14], Carboxylic acid [15], Glycoside [16], Cardiac glycoside [15,17], Anthraquinone [18], Carbonyl group [19], Saponin [20], Coumarin [21], Phlobatanin [22], were analyzed as per the standard procedure.

Treatment of Effluent

Required amount of algal extract was added to 100 ml of effluent and was left for 5 days. After five days TDS of the treated effluent were analyzed.

Estimation of TDS

Total dissolved solid present in treated and untreated effluents was analysed as per the standard procedure [23].

RESULTS AND DISCUSSION

Phytochemical analysis

Phytochemical results revealed that the terpenoids were absent only in EIEC, UEK, SEK, GLEC, CCCC and CCWC. Phenol was found to be absent in the aqueous extracts such as CAWC, ULWC, AWK, UWK, CCWC, HWK, GLWC, SWK and also in methanolic extracts of *Chaetomorpha sp.,* from Covelong and *Amphoroa sp.,* from Kanyakumari. Since solubility of phenol is very less at room temperature. Aqueous extracts showed absence of carboxylic acid except in *E.intestinalis* collected from Covelong and in case of chloroform extracts it was found only in ULCC and CACP. Seven extracts of ethanol showed presence of carboxylic acid except EFEC, CCEC and AEK. All the aqueous extracts showed presence of aminoacids and it was found to be absent in all benzene extracts except in EFBC and also absent in chloroform extract except in EFCC. Because of high solubility of amino acids in water and its solubility decreases towards non polarity [24]. Other extracts showed presence of amino acid except in ULEC, CACP, AEK, CAEC, HMK, SMK, CAMP, ULMC, EIMC, GLMC, and UMK. Phytochemical report showed that most of the extracts contained carbonyl compounds except in UEK, CAEP. HEK, AEK, CAEC, HMK, CAMP, CCMC, GLMC, UMK, CACP, CCCC, CACC, ACK, HWK, GLWC, EIWC. All the methanolic extracts showed presence of carbonyl compounds (**Data not shown**).

Reduction of Total Dissolved Solid (TDS)

The maximum permissible limit of TDS in waste water according to the National Environment Regulations (Standards for Discharge of Effluent into Water or on Land; S.I. No 5/1999; under section 26 and 107 of the National Environment Act, Cap 153) is 1200 mg/l in land and 500 mg/l in drinking water. Many methods have been adopted for reducing TDS in waste water such as distillation, electrodialysis, reverse osmosis, ion exchange method etc. In recent research microorganisms play a significant role in the treatment of waste water. Many different organisms live within the wastewater itself, supporting the breakdown of certain organic pollutants [25].

Microorganisms play a major role in the decomposition of organic waste; however, some microorganisms can cause health concerns to humans. These include bacteria and viruses present in the wastes produced [26]. Different herbs have been used to reduce TDS among which vettiver (*Vetiveria zizanioides*) showed highest reduction (55.93 %) [5]. Many adsorbents were used to remove TDS. Maruf Mortula and Sina shabani had stated that using of aggregated lime stone adsorbent reduce nearly 77 % of TDS from waste water [27]. However in this study, good reduction (Category A) was achieved by majority of algal extracts (Fig 1). The benzene extract of *Chaetomorpha sp*., aqueous extract of *Enteromorpha sp*., and chloroform extract of *Amphiroa sp*., showed very less reduction (Category C) (Fig 3). Among all extracts, ethanolic extract of *E. intestinalis* collected from Covelong showed highest reduction (97 %) in TDS of 50 mg/l which was highly lower than the permissible limit (1200 mg/l) of the National Environment Act. Category B type reduction was found in fifteen algal extracts (Fig 2). It was also comparatively higher reduction than the effluent treated with benzene extract of *M. oleifera* (69%) [28].

This study enables us to suggest that the presence of carbonyl groups might be the reason for the reduction of TDS. There is no report claiming this suggestion. Carbonyl group is a carbon double bonded to oxygen. Carbonyl group is classified into two types;

Type I: Has a group attached to the acyl group that can function as a leaving group.

acyl halides, acid anhydrides, esters, thioesters, carboxylates, and amides are carboxylic acid derivatives because they differ only by the chemical group that has replaced the OH group.

Type II: Does not have a group attached to the acyl group that can function as a leaving group.

H and alkyl or aryl (-R or -Ar) groups of aldehydes and ketones are too basic to be replaced by a nucleophile. A nucleophile is a chemical species that donates an electron pair to an electrophile to form a chemical bond in relation to a reaction. All molecules or ions with a free pair of electrons or at least one pi bond can act as nucleophiles.

Eg. Aldehyde and ketone.

Acid + Metal carbonate → Salt + Water + Carbon dioxide

For example:

$C_2H_5COOH + CaCO_3 \rightarrow C_2H_5COOH\ Ca + CO_2 + H_2O$

Welcher & Hahn had stated that all acetates are soluble in water and the insoluble calcium carbonate salts might have become soluble salts of carboxylic acid which may reduce the total dissolved solids present in the waste water [29]. In Category C, carbonyl compound was found in trace amount only in benzene extract of *Chaetomorpha antennina* collected from Puducherry hence it reduced 48 % of TDS.

Though carbonyl compounds were absent in Ethanolic extracts of *Ulva sp.* (89 % reduction) from Kanyakumari, *Chaetomorpha antennina* (87 % reduction) from Puducherry, *Hypnea sp.* (76 % reduction) from Kanyakumari; methanolic extract of *C.antennina* (79% reduction) from Puducherry and chloroform extract of *C.antennina* (75 % reduction) from Puducherry, they fall under category A. However these extracts indicated the presence of carboxylic acid which might be the reason for the highest reduction. Water extract of *Enteromorpha intestinalis* collected from Covelong showed 44 % reduction and chloroform extract of *Amphiroa sp.* collected from Kanyakumari showed less reduction of 25 % in which carbonyl compounds were absent. Among all solvents, benzene was found to be the best solvent system since all benzene extracts came under Category A reduction, except *C. antennina* from Puducherry which showed 48 % reduction. Among all seaweeds, all the extracts of *Ulva lactuca* collected from Covelong showed good reduction in TDS (Category A).

CONCLUSION

Environmental pollution is one of the most important issues facing humanity. It has been increasing exponentially in the past few years and has reached frightening levels in terms of its effects on human and other living creatures. Heavy metals are considered one of the important pollutants that have direct effect on man and animals. This may also contaminate groundwater resources and thus lead to a serious groundwater pollution problem. Though there are many methods available for treating effluent, most of them are not effective due to its high cost and technology. In this study, marine algal extracts were found to be the good alternate for reducing the TDS present in waste water than other commercial methods. In future, further more economic way of reducing TDS using algal extracts would be carried out.

REFERENCES

1. Sawyer, C.N., and McCarty P.L. (1967). Chemistry for sanitary engineers. (2nd edition), McGraw-Hill Series in Sanitary Science and Water Resources Engineering, McGraw-Hill, Toronto.
2. Tihansky, D.P. (1974) Economic damages from residential use of mineralized water supply. Water Resour. Res., 10(2): 145.
3. McQuillan, R.G and Spenst, P.G. (1976). The addition of chemicals to apartment water supplies. J. Am. Water Works Assoc., 68: 415.
4. Aaron Crotts. (1996). An Experimental technique in lowering total dissolved solids in wastewater. UG Thesis, University of Nevada, Las Vegas.
5. Aneez Ebrahim, Mohammed Ali, Gautham N.Jawahar and Sekarbabu Hariram. (2011). Preliminary attempt to reduce total dissolved solids in ground water using different plant parts. Int.J.Pharma and Biosci., 2(2): B414-422.
6. Wegelin, M. (1996). Surface water treatment by roughing filters. A design, construction and operation manual. Swiss Federal Institute for Environmental Science and Technology (EAWAG) and Department of Water and Sanitation in Developing Countries (SANDEC).
7. Krishnaprasad, M. (2012). Microbe for reducing total dissolved solids from wastewater, applied for patent W02012070060A1.
8. CCREM, (Canadian Council of Resource and Environment Ministers). (1987). Total dissolved solids. In: Canadian water quality guidelines. Prepared by the Task Force on Water Quality Guidelines. Environment Canada, Ottawa, March.
9. Clark, J.W., Viessman, W. Jr., and Hammer, M.J. (1977). Water supply and pollution control. (3rd edition). Harper & Row Publishers, New York, NY.
10. Salkowski, and Ernst Leopold. (1904). A Laboratory Manual of Physiological and Pathological Chemistry. New York: John Wiley & Sons.
11. Mace, M.E. (1963). Histochemical Localization of phenols in healthy and diseased tomato roots. Phytopathology, 16: 915-925.
12. Sofowora, A. (1993). Medicinal Plant and Traditional Medicine in Africa; Spectrum Books Limited, Ibadan. 1-12: 101-108.
13. Segelman, A.B., Fransworth, N.R., and Quimbi, M.D. (1969). False negative saponins test results induced by the presence of tannins. Lloydia, 32: 52-58.
14. Yasuma, A., and Ichikawa. (1953). Ninhydrin-schiff and alloxan- Schiff staining. A new histochemical staining method for proteins J.Lab clin Med., 41: 296-299.
15. Harborne, J.B. (1998). Phytochemical Methods—A Guide to Modern Techniques of Plant Analysis. 1stedn: Chapman and Hall; London, UK.
16. Ramakrishnan, S.K., Prasannan, G., and Rajan, R. (1994). Textbook of medical biochemistry. Orient Longman, New Delhi. India. 582.
17. Kokate, C.K., Purohit, A.P., and Gokhale, S.B. (2001). Carbohydrate and derived Products, drugs containing glycosides, drugs containing tannins, lipids and protein alkaloids. Text book of Pharmacognosy, (7^{th} edition).
18. Trease, G.E., Evans, W.C. (1997), Pharmacognosy, 4th edition, WB Saunders Company: UK, 50:150.

19. Venkatesan, D., Karrunakarn, C.M., Selva Kumar, S., and Palani Swamy, P.T. (2009). Identification of Phytochemical Constituents of *Aegle marmelos* Responsible for Antimicrobial Activity aga inst Selected Pathogenic Organisms. Ethnobotanical Leaflets, 13: 1362- 1372.
20. Kokate, C.K. (1999). Practical pharmacognosy.4th Edition.Vallaph prakashan publication, New Delhi, India. 115.
21. Kiran Kumari, S.P., Sridevi, V., and Chandana Lakshmi, M.V.V. (2012). Studies on Phytochemical screening of aqueous extract collected from fertilizers affected two medicinal plants, Journal of Chemical. Biological and Physical Sciences, 2(3): 1326-1332.
22. Pravin, S., Jogi1, and Akkewar, D.M. (2012). Phytochemical screening and antimicrobial activity of medicinal plant Pergularia daemia From Chandrapur Forest Region. International Journal of Natural Products Research, 1(3): 61-63.
23. Kotaiah, B., and Swamy, K.N. (1994). Environmental Engineering Laboratory Manual, Charotar Publishing House, Gujarat, India, 25-26.
24. Thomas, E., Needham, J.R. (1970), The solubility of aminoacids in various solvent systems, Ph.D Thesis, University of Rhode Island.
25. Taylor, C., Yahner, J., Jones, D., and Dunn, A. (1997). Wastewater in Pipeline, 8 (4).
26. Harris BL, Hoffman DW. and Mazac Jnr FJ, 2001, Reducing Contamination by Improving Household Wastewater Treatment, Blackland Research Centre Water Sciences laboratory.
27. Maruf Mortula., and Sina Shabani. (2012). Removal of TDS and BOD from Synthetic Industrial Wastewater via Adsorption. International Conference on Environmental, Biomedical and Biotechnology IACSIT Press Singapore, 41: 166-170.
28. Md Saduzaman., Sharmila, S., and Jeyanthi Rebecca, L. (2013). Efficacy of leaf extract of Moringa oleifera in treating domestic effluent. Journal of Chemical and Pharmaceutical Research, 5(2):139-143.
29. Welcher, F.J., and Hahn, R.B. (1963). Semi micro qualitative analysis. D.Van Nostrand Company USA.

TABLES

Table.1 Seaweed extracts using in this study

S.No	**Name of Seaweed**	**Collection Place**	**Water**	**Chloroform**	**Benzene**	**Methanol**	**Ethanol**
1	*Enteromorpha intestinalis*	Covelong	EIWC	EICC	EIBC	EIMC	EIEC
2	*Ulva sp.*	Kanyakumari	UWK	UCK	UBK	UMK	UEK
3	*Hypnea sp.*	Kanyakumari	HWK	HCK	HBK	HMK	HEK
4	*Grateloupia lithophila*	Covelong	GLWC	GLCC	GLBC	GLMC	GLEC
5	*Sargassum sp.*	Kanyakumari	SWK	SCK	SBK	SMK	SEK
6	*Chaetomorpha antennina*	Puduchery	CAWP	CACP	CABP	CAMP	CAEP
7	*Centerocerus clavulatum*	Covelong	CCWC	CCCC	CCBC	CCMC	CCEC
8	*Ulva lactuca*	Covelong	ULWC	ULCC	ULBC	ULMC	ULEC
9	*Enteromorpha flexuosa*	Covelong	EFWC	EFCC	EFBC	EFMC	EFEC
10	*Chaetomorpha attenina*	Covelong	CAWC	CACC	CABC	CAMC	CAEC
11	*Amphiroa sp.*	Kanyakumari	AWK	ACK	ABK	AMK	AEK

Table.2 Different Categories of Reduction

S.No	**Category**	**Percentage Reduction**	**Remark**
1	Category A	75 % - 100 %	Good
2	Category B	50 % - 75 %	Medium
3	Category C	Below 50 %	Poor

Table.4 TDS content of effluent after treatment

TDS of Untreated effluent: 1600mg/l		
S.No	**Extract**	**TDS of Treated Effluent mg/l**
1.	EIMC	400
2.	SMK	200
3.	UMK	600
4.	HMK	100
5.	GLMK	500
6.	EICC	200
7.	UCK	800
8.	HCK	400
9.	GLCC	200
10.	SCK	426
11.	EIBC	139

12.	UBK	137
13.	HBK	108
14.	GLBC	98
15.	SBK	198
16.	EIEC	50
17.	UEK	180
18.	HEK	380
19.	GLEC	480
20.	SEK	200
21.	EIWC	900
22.	UWK	500
23.	HWK	700
24.	GLWC	800
25.	SWK	800
26.	CAMC	150
27.	AMK	200
28.	CABC	100
29.	ABK	200
30.	CACC	800
31.	ACK	1200
32.	CAEC	500
33.	AEK	450
34.	CAWC	230
35.	AWK	500
36.	CCWC	608
37.	CCEC	388.8
38.	CCBC	406.4
39.	CCCC	462.4
40.	CCMC	385.6
41.	ULWC	400
42.	ULEC	144
43.	ULBC	240
44.	ULCC	128
45.	ULMC	336
46.	EFWC	480
47.	EFEC	272
48.	EFBC	400
49.	EFCC	352
50.	EFMC	288
51.	CAMP	330
52.	CAEP	210
53.	CAWP	600
54.	CABP	830
55.	CACP	400

GRAPHS

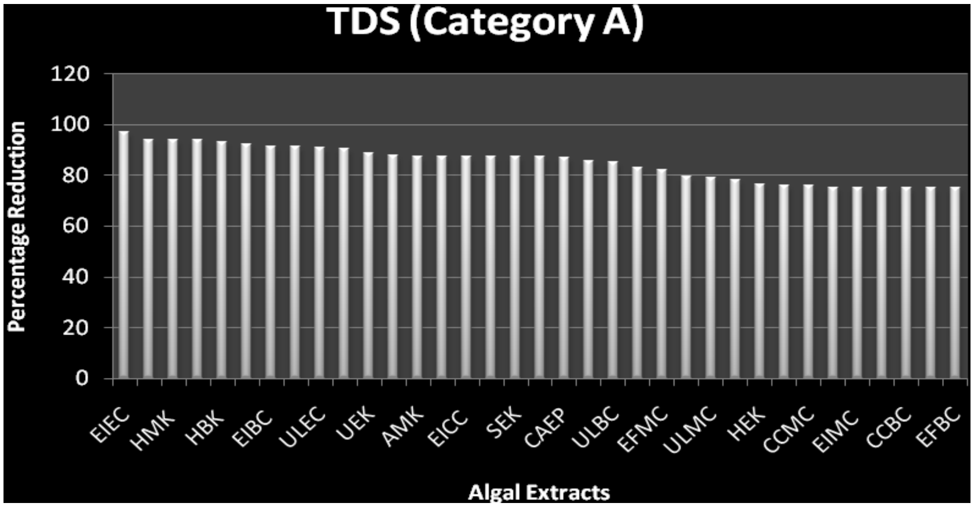

Fig 1 Reduction in TDS (Category A)

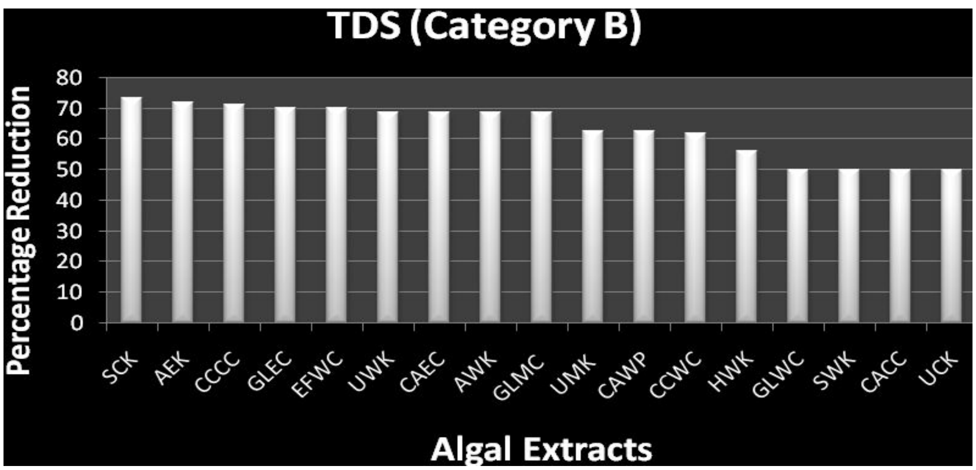

Fig 2 Reduction in TDS (Category B)

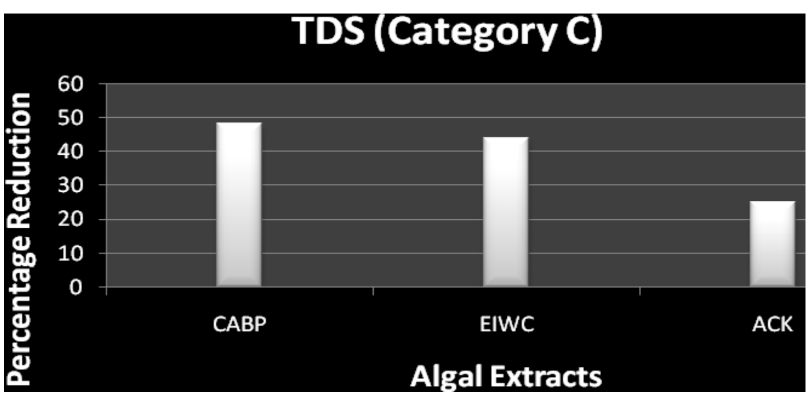

Fig 3 Reduction in TDS (Category C)