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Nitrogen Removal from Sewage Water with Hybrid Technology

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***Abstract*— Work describes treatment of community waste water in a Constructed Soil Filter System (CSF) the waste water brings about removal of COD and Nitrogen. A hybrid system titled Constructed Soil Filte (CSF) and Organic Matter Filter (OMF) has also been evaluated. The results indicate that Anammox might also be operating in the system investigated. It is concluded that in the combination of CSF and OMF can purify waste water to drinking water quality. The hybrid system succeeded in conducting experiments with the combination of CSF and OMF Treatment of Sewage water.**

***Keywords*— Constructed Soil Filter System; Organic Matterfilter; Anammox; Sewage water ; hybrid reactor;**

I. INTRODUCTION

The concept of duel water systems, one high quality and one only partially treated has been muted for decades, and in the 1970s many new buildings were constructed with duel plumbing systems to facilitate this futuristic idea [5]. Removal of the nitrogen content of the waste water before entering in to the ground water from septic tanks is essential; In order to fulfill the strict effluent limits introduced for the protection of the sensitive receiving bodies. High strength nitrate wastewater discharges may cause an alarming increase in nitrate level of ground water and nearby water bodies. High levels of nitrate in drinking water can cause methehemoglobinemia in infants whereby blood's ability to carry oxygen is reduced. Biological nitrification and denitrification and Anammox are the most studied processes for nitrogen removal from wastewaters. In Biological treatment processes, cell growth occurs simultaneously with the oxidation of organic or inorganic compounds, the ratio of amount of Biomass produced to the amount of substrate consumed (gram biomass/gram substrate) is defined as the biomass yield, and typically is defined relative to the electron donor used [12]. It can be estimated that bacteria consist of roughly 50% protein and that the Nitrogen content of protein is about 16% and for synthesis of 1 g of Bacterial biomass, about 0.08g of ammonia-N is required. To eliminate Ammonia that is not used for cell growth during wastewater treatment, it must first be Nitrified and then Denitrified to molecular Nitrogen or anaerobically oxidized with Nitrite. *Nitrosomonas* sp. must oxidize 30 g NH_3 to form 1 g of cell dry mass [18]. Heterotrophic Nitrifiers oxidize reduced Nitrogen compounds, such as hydroxylamine and aliphatic and aromatic Nitrogen-containing compounds, but in contrast to autotrophic Nitrification, no energy is gained by Nitrate formation. For this reason an organic substrate must be respired to satisfy the energy metabolism [2]. The disadvantage of this conventional Denitrification is instead of Nitrate, many denitrifying bacteria can use NO_2^-, NO, or N_2O as terminal electron acceptors. NO, N_2O are green house gasses and cause global warming. ANAMMOX bacteria are ubiquitous; recently, substantial N-losses have been reported for various soil, sediment, and aquatic systems [8]. They preferentially utilize carbon dioxide as the sole carbon source. Their importance in the global Nitrogen cycle is immense. They are estimated to contribute up to 50% to the removal of fixed Nitrogen from the oceans. The ANAMMOX bacteria are effective in wastewater treatment. The Anammox plant did not require aeration, or an organic carbon-containing energy source [4]. Relative to a conventional Nitrification/Denitrification process, the ANAMMOX process produced 88% less CO_2, as a consequence, power consumption was reduced by 60%, very little sludge was produced and the overall operating cost was lowered by 90% [14]. CSF system is also called Soil Biotechnology (SBT) [10].In the present work, formulated soil environment wherein fundamental processes of nature viz. respiration, mineral weathering and photosynthesis bring about the bioconversion and the organic matter was used in OMF and successfully removed nitrogen from wastewater.

II. EXPERIMENTAL PROCEDURE

A. Experimental plan

Characteristics of soil medium used is shown in Experimental set up is given in Fig.1. consists of a feed tank (20 liters), reaction vessel (20 liters) with soil media (CSF), Organic matter filter (OMF) column (0.5 liter), with soil media, collection tank, a peristaltic pump (0-300 mL/min) & (0-10 mL/min) distributor arrangement and Experiments were conducted for flow 50 mL/min in 20 liter, 5 mL/min in 0.5 liter. Organic Matter column contain saw dust having water holding capacity of 1/3rd of its volume, rich in organic carbon which is used up in nitrate removal. The media is equal volumes of partially weathered deccan trap basalt rock of suitable mineral composition locally known as "Murram" and rock wool. Rock wool is a man made mineral fiber; it is manufactured by melting basaltic rock and spinning the melt into fibers. Immediately following spinning a binder is added to the fiber, compressed and cured into larger slabs. As the rock wool is produced from basaltic rock it possess a mineral balance that is inert & non reactive. The two stage process basically involves: (i) CSF (ii) Organic matter. Fig. 1. Shows schematic of the process together with layout of

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media. In 1st stage waste water is passed through CSF, and then the effluent from CSF was passed through OMF. The system consists of raw water tank, bioreactor and storage tank with associated piping and pumping arrangements. Synthetic waste water of sewage characteristics was prepared with different C/N ratios 1.86, 3.32, 5.4 and 10.8 with the different nitrogen compounds (Table 1, 2, and 3) and passed through hybrid reactor, water quality at inlet and outlets were analyzed, for carbohydrate content denoted as COD (Chemical Oxygen Demand), ammonia –N, nitrite –N, nitrate –N were carried as per APHA. The process was carried out at ambient temperature. Water quality at inlet and outlet were analyzed as per standards, accuracy of the measurement involved in wastewater and media analysis is given in Table-4

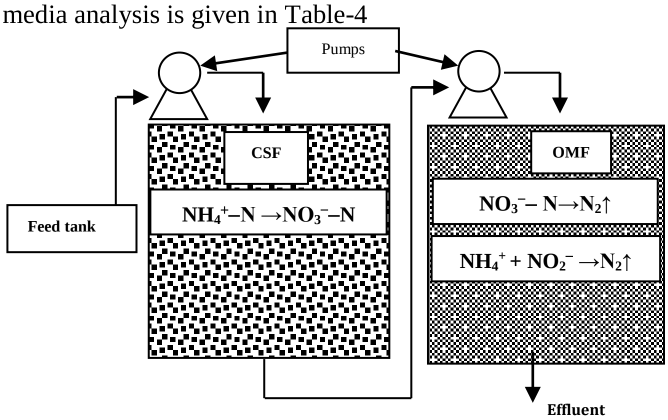

Fig. 1 Flow diagram of experimental set up for hybrid reactor of CSF and OMS.

Table1. Composition of synthetic waste water (COD-500) (Acetate + Nitrite + Ammonia)

Chemicals	Weights in mg to be added per Liter of water		
	Medium A	Medium B	Medium C
$CH_3COONa.3H_2O$	1050	1050	1050
NH_4Cl	173.71	97.32	59.83
$NaNO_2$	266.36	149.23	61.75
Na_2HPO_4	77	43.1	27.5
KH_2PO_4	38.6	21.6	13.7
$MgSO_4$	57.6	32.3	19.2
Total C	185.15	185.15	185.15
Total N	99.54	55.57	34.29
C/N	1.86	3.32	5.4

Table 2. Composition of synthetic waste water (COD-500) (Acetate Carbon, Ammonia, Nitrate)

Chemicals	Weights in mg to be added per Liter of water		
	Medium A	Medium B	Medium C
$CH_3COONa.3H_2O$	1050	1050	1050
NH_4Cl	173.71	97.32	59.83
$NaNO_3$	323.76	177.53	109.77
Na_2HPO_4	77	43.1	27.5
KH_2PO_4	38.6	21.6	13.7
$MgSO_4$	57.6	32.3	19.2
Total C	185.15	185.15	185.15
Total N	99.54	55.57	34.29
C/N	1.86	3.32	5.4

Table 3. Composition of synthetic waste water (COD-500) (Acetate Carbon, Nitrate)

Chemicals	Weights in mg. to be added per Liter of water		
	Medium A	Medium B	Medium C
$CH_3COONa.3H_2O$	1050	1050	1050
$NaNO_3$	604.3	337.36	208.17
Na_2HPO_4	77	43.1	27.5
KH_2PO_4	38.6	21.6	13.7
$MgSO_4$	57.6	32.3	19.2
Total C	185.15	185.15	185.15
Total N	99.54	55.57	34.29
C/N	1.86	3.32	5.4

Table 4. Accuracy of the measurement involved in wastewater and media analysis

No	Parameter	Accuracy of measurement	Method
1	COD	0.3mg/l	Closed reflux titrimetric method (5220 C, APHA, 21^{ST}
2	NH_4^+	0.03mg/l	ELIT double junction
3	NO_3^-	O.4mg/l	ELIT double junction
4	NO_2^-	0.02 mg/L	Calorimetric method (4500 – NO_2^- B, APHA, 21^{ST} Edition)

III. RESULTS AND DISCUSSION

Experiments conducted with C/N ratio 10.8 in 20 liter column removal of carbon was observed significantly, but with increase in C/N ratio there is an increase in energy consumption this also observed by Yu X et al [19], the effect of carbon-to-nitrogen ratio (C/N) as well as interaction on *Colletotrichum coccodes* growth and sporulation in submerged flask culture reported. During biomass growth, energy required to synthesize the monomers needed to make the macromolecules that form the structural and functional components of the cell, this suggests that more energy would be required for a culture to grow in a minimal medium containing only a single organic compound as the carbon and energy source than in a complex medium in which all required monomers were supplied [6]. Significant formation of NO_3^-–N was also observed as shown in Tables 5, 6, 7 and 8. In CSF columns 1.A, 2.A, 3.A, and also observed in on site waste water treatment SBT Plant [11]. So to remove NO_3^- – N from effluent coming from CSF organisms require high energy. A surplus of carbon source must be supplied, since the wastewater is not free of oxygen, and part of the carbon source is respired until anoxic conditions are achieved. To supply surplus energy, enough carbon to be present in the media for generation of bio-energy, and CO_2. This was done by passing effluent of CSF through Saw dust which is rich in organic carbon. Hence efficient removal of NO_3^- - N was observed in Tables – 5, 6, 7 and 8 in columns 1.B, 2.B, 3.B in OM rector.

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Table 5. Results using synthetic waste water CSF (20L) + OMF (0.5 L) Carbon, NH_4^+ - N of COD 250

Column	Exp. No.	C/N	Flow rate	COD (mg/l)		NH_4–N (mg/l)		NO_2- N (mg/l)		NO_3-N (mg/l)		Total Nitrogen (mg/l)	
			(ml/min)	Inf	Eff	Inf	Eff	Inf	Eff	Inf	Eff	Inf	Eff
CSF	1.A	10.8	50	500	224.6	11.88	1.46	0.11	0.28	1.62	1.98	13.61	3.72
OMF	1.B.	10.8	7	230	27	1.28	0.68	0.51	0.26	2.7	0.68	4.49	1.62
CSF	2.A.	10.8	50	500	249.6	13.2	1.62	0.12	0.31	1.8	2.2	15.12	4.13
OMF	2.B.	10.8	7	262.4	30	1.42	0.76	0.57	0.29	3	0.76	4.99	1.81
CSF	3.A.	10.8	50	500	274.6	14.52	1.78	0.13	0.34	1.98	2.42	16.63	4.54
OMF	3.B.	10.8	7	262.4	33	1.56	0.84	0.63	0.32	3.3	0.84	5.49	1.99

Table – 6: Results using synthetic waste water CSF (20L) + OMF (0.5 L) Carbon, NH_4^+ - N of COD 500

Column	Exp. No.	C/N	Flow rate	COD (mg/l)		NH_4–N (mg/l)		NO_2- N (mg/l)		NO_3-N (mg/l)		Total Nitrogen (mg/l)	
			(ml/min)	Inf	Eff	Inf	Eff	Inf	Eff	Inf	Eff	Inf	Eff
CSF	1.A	10.8	50	500	224.6	11.88	1.46	0.11	0.28	1.62	1.98	13.61	3.72
OMF	1.B.	10.8	7	230	27	1.28	0.68	0.51	0.26	2.7	0.68	4.49	1.62
CSF	2.A.	10.8	50	500	249.6	13.2	1.62	0.12	0.31	1.8	2.2	15.12	4.13
OMF	2.B.	10.8	7	262.4	30	1.42	0.76	0.57	0.29	3	0.76	4.99	1.81
CSF	3.A.	10.8	50	500	274.6	14.52	1.78	0.13	0.34	1.98	2.42	16.63	4.54
OMF	3.B.	10.8	7	262.4	33	1.56	0.834	0.63	0.32	3.3	0.84	5.49	1.99

Table 7. Results using synthetic waste water CSF (20L) + OMF (0.5 L) Carbon, NH_4^+ - N of COD 1000

Column	Run No.	Exp. No.	C/N	Flow rate (ml/min)	COD (mg/l)		NH_4–N (mg/l)		NO_2-N (mg/l)		NO_3-N (mg/l)		Total Nitrogen (mg/l)	
					Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.	Inf.	Eff.
CSF	1	1.A	10.8	50	1000	495	27.9	8.28	0.13	0.28	1.8	1.98	29.83	10.54
OMF		1.B.	10.8	7	490	225	5.94	1.8	0.42	0.11	1.89	0.99	8.25	2.9
CSF	2	2.A.	10.8	50	1000	605	34.1	10.12	0.15	0.34	2.2	2.42	36.45	12.88
OMF		2.B.	10.8	7	550	275	7.26	2.2	0.52	0.13	2.31	1.21	10.09	3.54
CSF	3	3.A.	10.8	50	1000	550	31	9.2	0.14	0.31	2	2.2	33.14	11.71
OMF		3.B.	10.8	7	550	250	6.6	2	0.47	0.12	2.1	1.1	9.17	3.22

Table 8. CSF (20L) + OMF (0.5 L) Acetate Carbon, NH_4^+ - N, NO_3^- N of COD 250

Column	Run No.	Exp. No.	C/N	Flow rate	COD (mg/l)		NH_4–N (mg/l)		NO_2-N (mg/l)		NO_3-N (mg/l)		Total Nitrogen (mg/l)	
				(ml/min)	Inf	Eff	Inf	Eff	Inf	Eff	Inf	Eff	Inf	Eff
CSF	1	1.A.	10.8	50	250	86.4	3.4	0.97	0.12	0.46	4.2	6.9	7.724	8.335
OMF		1.B.	10.8	7	83.2	32	0.85	0.7	0.93	0.12	12.6	1.5	14.38	2.324

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IV. CONCLUSION

Hybrid reactor with a combination of CSF and OMF can remove total Nitrogen from 10mg/L to < 1.5mg/L, and COD from 250 – 500 to 11 – 30mg/L As per my knowledge this extent of removal was not achieved by any technology. These removals from waste water will be accounted through bioassimilation via sorption by soil microflora through Anammox process. It can be lost to atmosphere through Nitrification-denitrification and anammox processes. NO_2^--N, the intermediate product of Nitrification, being consumed immediately in the Nitrification reaction is least stable. Total Nitrogen removal in all three combinations of synthetic media is comparatively almost drinking water standards were observed. Considering the existence of varied microbial ecology and ecological niche in CSF, these bioconversions could occur. Rich microbial ecology, high enzymatic activities, competitive hydrodynamic features and intelligent engineering of ecology has been reflected in the form of C&N removal from wastewater in CSF, OMF.

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