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Activated Sludge Adsorption of Heavy Metals in a Membrane Biological Reactor Operated for Reclamation and Reuse of Recirculating Aquaculture System Wastewater

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Recirculating aquaculture systems (RAS) can be operated to allow for a high degree of water reuse. However, application of solids collection mechanisms (gravity settling units, granular media filters, and rotating microscreen drum filters) to remove particulates from fish culture process water produce backwash / underflow that must be treated before discharge from the fish culture facility. Membrane biological reactors (MBR) are highly scalable wastewater treatment systems that couple an activated sludge process with a water filtration apparatus capable of producing high quality effluent. The activated sludge process utilized in a MBR allows for nitrification, denitrification, and phosphorus removal as microorganisms are subjected to alternating aerobic, anoxic, and anaerobic environments. Another phenomenon associated with activated sludge is the capacity for microorganisms to adsorb heavy metals introduced into the waste stream from fish feed vitamin / mineral packs, corrosion of metal pipe fittings and other components of RAS equipment, and perhaps pipe and vessel materials. Consequently, the potential exists for reduced metals concentration in MBR effluent water (i.e., permeate) and increased metals concentration in the activated sludge, which can have implications on removal, land application, or alternate use of waste activated sludge. Activated sludge solids retention time (an estimate of sludge age) can influence heavy metals adsorption capacity. This experiment will determine the effect of solids retention time (SRT) on metals adsorption. Also, as a control evaluation, metals concentration in activated sludge will be compared to metals concentration in gravity thickened sludge. Preliminary data (Table 1) indicate higher metals concentration in the activated sludge (% Solids = 1.5 ± 0.1, SRT = 23 days) as compared to the gravity thickened sludge (% Solids = 10.3 ± 2.0). Also, preliminary data (Table 2) show that processed MBR effluent (TSS < 1) and spring water (TSS < 1) are comparable in terms of heavy metals concentration.

Table 1 – Indicates heavy metals concentrations in a MBR activated sludge (SRT = 23 d) and heavy metals concentration in a gravity thickened sludge. (Ti, Mo, Pb, As, B, Be < detection limit at both sampling locations).

Site	Al	Mn	Fe	Cu	Ni	Co	Cd	Mg	Cr	Zn	Sr	Li	Ba
Activated Sludge	2434 ±	369 ±	2148 ±	170 ±	75 ±	73 ±	37 ±	3423 ±	65 ±	429 ±	270 ±	16 ±	101 ±
(mg/kg - dry)	596	58	765	22	n/a	67	n/a	620	n/a	83	46	5	16
Gravity Thickened	1101 ±	214 ±	1753 ±	109 ±	7 ±	20 ±	5 ±	1565 ±	11 ±	284 ±	117 ±	4 ±	48 ±
Sludge (mg/kg - dry)	471	56	524	30	6	18	5	378	9	78	25	1	12
EPA Land Application													
Limit (mg/kg - dry)				4300	420		85			7500			

Table 2 – Indicates heavy metals concentrations (Plus N & P) in MBR effluent and the spring water used as make up water in the fish culture systems. (Be, Ti, V, Cr, Fe, Ni, Pb, Mo, B, Li < detection limit at both sampling locations).

Site	Al	Mn	Cu	Co	Mg	Zn	Sr	Ba	As	Total N	Total P
MBR Effluent (mg/L)	<det	0.01 ± 0.00	<det	0.005 ± n/a	14 ± 0	<det	0.94 ± 0.03	0.04 ± 0.00	0.02 ± 0.00	2.0 ± 0.4	2.6 ± 0.2
Spring Water (mg/L)	0.03 ± n/a	0.00 ± 0.00	0.01 ± 0.00	0.004 ± n/a	13 ± 0	0.03 ± n/a	0.99 ± 0.04	0.06 ± 0.01	<det	2.7 ± 0.4	0.04 ± 0.02