Nitrates in Aquarium Water.

By

C. Honig,

Laboratory of Microbiology, University of Amsterdam.

It is known that considerable amounts of nitrates accumulate in sea-water which has been circulating in an aquarium stocked with fish and marine animals. An amount equivalent to 1 gram $NaNO_3$ per litre was found in the Aquarium of the Koninklyk Zoölogisch Genootschap Natura Artis Magistra in Amsterdam.

These amounts of nitrate are never found in natural sea-water and whereas it is not quite certain whether such quantities of nitrates themselves are absolutely harmless, they cause a decrease in pH by substituting CO''_3 and HCO''_3 ion by NO'_3, and they may lead to an undesirable formation of injurious nitrates as is described below.

The rate of production of nitrate and dissolved phosphate was followed in a tank stocked with fish, having a capacity of 1·3 cubic metres. During a month when the water was being continuously passed through a filter at a rate of 20 cubic metres per hour, the production was found to be 12·4 mg. nitrate-nitrogen per litre and 0·87 mg. P_2O_5 per litre. During the following month when the filter was kept out of action and the air supply carefully regulated, the production was found to be 10·6 mg. nitrate-nitrogen and 0·24 mg. P_2O_5 per litre. At the end of the month the water became turbid and had to be filtered.

Provided the water is aerated, the ammonia (which never amounts to more than 0·1 mg. per litre daily) originating from the breakdown of albuminoids is oxidised by nitrifying bacteria to nitrites and nitrates, a process which is stimulated by a small amount of organic matter and is not affected by filtration.

The reverse process—the reduction of nitrate *via* nitrite to nitrogen—is not likely to occur in water nearly saturated with oxygen and containing only a small amount of dissolved organic substances, although denitrifying bacteria are always present.

An experiment was made in which the organic substances suitable as food for the last-mentioned bacteria were increased. A tank stocked with fish, having a capacity of 1·3 cubic metres of sea-water was brought to a pH of 8·2 by the addition of lime, and a quantity equivalent to the addition of 0·6% of sodium lactate dissolved in it. The water in the tank

was then kept continuously passed through a filter and was thoroughly aerated. Analyses were made at frequent intervals of the ammonium, nitrite, nitrate, total nitrogen and phosphate content of the water. A measure of oxidisable organic matter present was obtained by titrating with decinormal potassium permanganate. The estimations were made in the water that flows directly from the filter (F) and in the water in the tank (B). F is therefore the purified water, B the water contaminated by the fishes.

After the addition of lactate the water became turbid and a considerable amount of nitrite was found in the water, while the amount of nitrate and of total inorganic nitrogen decreased, as shown in the Table. It is considered that the added lactate caused the denitrifying bacteria to develop. Later, when the lactate had been partly used up, the analyses showed oxidation of nitrite to nitrate to be taking place. The increase in nitrate started some four days after the addition of lactate, when the value for oxidisable organic matter had fallen to about 30. It is considered that an equilibrium is attained at a given moment between the activities of the denitrifying and the nitrifying bacteria and that nitrite appears when the denitrifying bacteria have insufficient lactate left. After a second addition of lactate on the 16th, the remaining nitrite and nitrate rapidly disappeared.

Throughout the experiment the concentration of ammoniacal nitrogen remained low, the ammonia formed being rapidly and almost completely oxidised. Repetition of the experiment after addition of potassium nitrate to the water gave a similar result. It was also found that, instead of lactate, tartrate may be used and that without filtration the water remained turbid and that denitrification was neither so quick nor so complete.

The turbidity is caused by bacteria, both cocci and rods. After the treatment with lactate followed by the disappearance of nitrates, the water supported fish life in a healthy condition.

SUMMARY.

The formation of nitrate in the water of an aquarium tank stocked with fish was followed. As much as 1 gram per litre expressed as sodium nitrate was found.

By adding lactate or tartrate to the water the development of denitrifying bacteria brought about almost complete removal of the nitrates and nitrites in the water.

The experiments form part of an investigation made under the direction of Dr. Jan Smit.

TABLE I.

Sea-water Filtered under addition of Lactate.

	Date.	Temp. °C	·pH	Water.	NH_3N mg./L.	NO_2N mg./L.	NO'_3N mg./L.	Total Inorg.N mg./L.	Org.N. mg./L.	P_3O_5 mg./L.	$KMnO_4$ c.c.O.In/L.
F	28.5.32	15·5°	8·2	clear	0·2	0	53·5	58·7			
B			8·2	,,	0·3	trace	59·2	59·5			
F	1.6.32	16°	8·2	,,	0·20	,,	58·5	58·7	0·26	3·96	4·84
B			8·2	,,	0·16	,,	58·5	58·7	0·53	3·96	4.84
→											
F	4.6.32	16·5°	8·2	,,	0·16	,,	37·1	37·3		3·65	40
B			8·2	,,	0·27	0	53·8	54·1		3·65	40
F	6.6.32	16°	8·1	turbid	0·28	4·87	24·7	29·9			58
B			8·1	,,	0·23	2·74	26·9	29·8			80
F	7.6.32	16°	8·1	,,	0·33	12·4	1·3	14·0			30·2
B			8·1	,,	0·51	11·3	2·4	14·2			34·0
F	8.6.32	16°	8·1	,,	0·77	12·2	2·2	15·2		1·90	28·6
B			8·1	,,	0·50	12·2	2·8	15·5		1·90	30·2
F	11.6.32	16·5°	8·1	,,	1·59	12·5	6·9	21·0		2·00	26·5
B			8·1	,,	1·27	12·1	6·6	20·0		2·00	27·5
F	13.6.32	18·5°	8·1	clear	0·80	14·6	7·3	22·7		2·56	26·9
B			8·1	,,	1·06	14·6	7·3	23·0		2·56	27·1
F	15.6.32	18·5°	8·2	,,	0·26	12·3	11·9	24·5	4·44	2·83	24·6
B			8·2	,,	0·22	12·3	10·5	23·0	2·72	2·83	25·1
→											
F	16.6.32	19°	8·2	turbid	0·24	9·6	0	9·8		2·07	96
B			8·2	,,	0·20	11·4	2·7	14·3		2·17	117
F	18.6.32	19°	8·2	,,	0·26	0	0·12	0·38		2·17	109
B			8·2	,,	0·25	0	0·12	0·37		2·17	108
F	20.6.32	17°	8·2	,,	0·17	0	0	0·17	1·22	2·13	55·8
B			8·2	,,	0·16	0	trace	0·16		2·13	56·2
F	22.6.32	16·5°	8·1	clear	0·28	0	0·18	0·46		2·47	58·1
B			8·1	,,	0·39	0	0·07	0·46		2·40	60·3
F	30.6.32	18°	8·1	,,	0·51	0	0·6	0·57		1·82	10·8
B			8·1	,,	0·58	0	0·6	0·64		1·88	11·0

→ Addition of organic substance.
F = filtered water.
B = water in the tank.
(The difference between the values of F and B on the same day is affected by the filtration.)