LXII. DENITRIFICATION AS A MEANS OF SEWAGE PURIFICATION.

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THE process of denitrification is of importance not only in agriculture, but also in the problem of sewage disposal, because it is capable of effecting purification to a considerable degree. It has been recognised for some time that the presence of nitrates in an effluent is desirable, because, should the dissolved oxygen be expended locally by fermentation of organic matter in a river, the supply of nitrates is then called upon to destroy some of the fermentable matter, and a possible nuisance is prevented.

It is known that the process of denitrification is due to the presence in the sewage of micro-organisms. Many different species can effect the reduction of nitrates, the products of the reaction depending on the kind of organism, *e.g.* nitrogen, nitrites, oxides of nitrogen, ammonia. *B. coli communis*, for example, forms nitrites. The reaction consists in the oxidation of carbonaceous matter by nitrate through the agency of the denitrifying organisms and can be represented thus:

and it has accordingly been found that when a filter effluent containing nitrates is added to sewage, there is a rapid disappearance of the nitrate. At the present time the nitrate from sewage purification plants is discharged into the rivers, and although it may there act as reserve oxidising material, it undoubtedly encourages the growth of aquatic weeds.

The loss of nitrate in this way is very wasteful, as it could be much more usefully employed in oxidising fermentable material present in the sewage and thus contribute to the process of sewage purification. This could be effected by passing a portion, *e.g.* one-half of the sedimentation tank liquor through filters, and then mixing the filter effluent which would now contain nitrates with the remaining portion of tank liquor. Denitrification would take place, and some of the oxidisable material present in the sewage would then be destroyed. In this way an economy might be introduced, as a smaller area of filtering material would be sufficient for purifying the sewage.

The experimental work described in this paper aims at determining the degree of purification that can be effected in the process of denitrification.

1. Experiments were first of all carried out to ascertain to what extent nitrates could be reduced by the oxidisable constituents of sewage.

For this purpose sedimentation tank liquor was mixed with an equal volume of a solution of potassium nitrate or a filter effluent. The mixtures were kept in stoppered bottles at 20° C. for varying periods, and the amounts of nitrate present before and after the experiment were determined by the colorimetric phenolsulphonic acid method.

Nitrates. Parts per 100,000 (as N).

	Original mixture	After 24 hours	After 48 hours	After 96 hours
1. Tank liquor + distilled water	0.00	0.00	—	0.00
Tank liquor + KNO ₃ solution	2.50	1.28	—	Trace
Tank liquor + KNO ₃ solution	5.00	3.10	—	2.50
2. Tank liquor + KNO ₃ solution	2.50	0.10	—	—
	5.00	0.00	—	—
	10.00	0.00	—	—
3. Tank liquor + KNO ₃ solution	2.50	—	Absent	—
	5.00	—	1.00	—
4. Filter effluents alone	4.76	1.00	—	—
	16.66	3.33	—	—
5. Tank liquor + KNO ₃ solution	5.00	—	1.66	—
	2.50	—	0.00	—
6. Tank liquor + filter effluent	1.50	—	Trace	—
	1.25	—	Trace	—
7. Tank liquor + KNO ₃ solution	2.50	—	0.75	—
	5.00	—	3.33	—

A survey of the tabulated results shows that sewage constituents are able to reduce considerable amounts of nitrate in a comparatively short time. Thus, in one experiment 10 parts per 100,000 of nitrate disappeared completely in 24 hours. In another case, a concentration of 16.66 parts was reduced to 3.33 in the same time.

Mixture	Period of preliminary incubation	Pts. per 100,000 Nitrates present in mixture		Pts. per 100,000 "Dissolved oxygen absorbed" by mixture after the preliminary incubation		
		Before	After	1 day	3 days	5 days
1. Tank liquor and water	48 hours	0.00	0.00	3.44	7.00	8.92
Tank liquor and nitrate solution	"	5.00	1.66	0.60	3.46	4.46
" " "	"	2.50	0.00	1.34	3.44	7.20
2. Tank liquor and water	"	0.00	0.00	—	—	2.90
" " filter effluent	"	1.25	Trace	—	—	2.07
Filter effluent and water	"	1.25	1.11	—	—	0.50
3. Tank liquor and water	"	0.00	0.00	—	—	5.59
" " nitrate solution	"	2.50	0.75	—	—	0.92
" " " "	"	5.00	3.33	—	—	1.14
4. Tank liquor and water	"	0.00	0.00	—	—	4.66
" " filter effluent	"	1.50	Trace	—	—	3.85
Filter effluent and water	"	1.50	1.33	—	—	0.20

2. Experiments were next carried out to ascertain to what extent the purification of sewage could be effected through the utilisation of nitrates

by the reducing micro-organisms present in the sewage. For this purpose a series of quantitative experiments were set up in which mixtures of (1) sedimentation tank liquor and an equal volume of water, and (2) sedimentation tank liquor and an equal volume of nitrate solution or filter effluent were incubated at 20° C. in closed bottles for definite periods, *e.g.* 48 hours. At the end of this period the "dissolved oxygen absorbed in 5 days¹" (or sometimes in shorter periods) was then estimated for each mixture.

When filter effluents were used, the "dissolved oxygen absorbed in 5 days" figures were also determined after dilution with an equal volume of water and incubation for two days.

The results are tabulated above.

CONCLUSION.

The results show that the dissolved oxygen absorption figures for the mixtures of tank liquors and nitrate solutions or filter effluents are very much lower than those for the corresponding mixture of tank liquor and water only. As the dissolved oxygen absorption is a measure of the amount of oxidisable carbonaceous or putrescible matter present in the sewage, the results indicate that incubation of the sewage with nitrate solutions and filter effluents leads to the destruction of a considerable amount of this oxidisable material. With concentrations of nitrate amounting to about 5 in 100,000 it is seen that the degree of purification is enormous, while with lower concentrations, *e.g.* 1.25 parts, the purification is still appreciable.

Another point emerging from the results is that the extent of destruction of the oxidisable matter is not necessarily proportional to the amount of nitrate present.

In one of the experiments (1) the dissolved oxygen absorbed in one day, three days and five days was estimated. A comparison of this series of results reveals the fact that the one day tests indicated a higher degree of purification through denitrification than the three and five days tests. From this it is concluded that the very readily fermentable matter is first attacked in the process of denitrification, and that the more resistant oxidisable matter is largely left and its presence is indicated in the prolonged dissolved oxygen tests.

As it is this readily oxidisable material that causes the nuisance in river pollution, the value of employing the nitrates produced in the filters for further sewage purification is self-evident. In fact, the dissolved oxygen tests summarised above justify the view that in practice considerable economy could be introduced in sewage purification by mixing part of the sedimentation tank liquor with the filter effluent and thus employing the nitrate present for destruction of the more readily fermentable material. By this means a smaller filtering area would be sufficient to effect sewage purification.

¹ Winkler's method was employed for estimating dissolved oxygen.