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THE ADSORPTION OF RADIOACTIVE
IODINE 131 ON MUD

by

W.R. Ellis and Marion E. Gardner

SUMMARY

The effect of potassium iodide carrier concentration on the adsorption of iodine 131, as iodide, mud is indicated. This work was initiated to provide information for a field test on the efficiency of power station cooling ponds which was carried out in conjunction with the Electricity Commission of New South Wales.

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1. INTRODUCTION

The Electricity Commission of New South Wales is carrying out a large scale investigation of the efficiency of power station cooling ponds. As part of this investigation, it was decided to trace the movement of the cooling water in a particular pond at Maitland, N.S.W., by means of the radioactive isotope iodine 131. The complete investigation will be fully reported in a separate A.A.E.C. report.

The iodine 131, as iodide, was to be added to the lake at the point of entry of the cooling water, and its movement throughout the body of the lake traced by means of scintillation counters and Geiger counters. The pond itself, which was entirely self-contained, covered an area of approximately 40 acres with a maximum depth of 25-30 feet and a water capacity of approximately 1.3×10^8 gallons.

The bottom of the pond consisted of a mixture of mud and sand and it was necessary to determine the amount of potassium iodide carrier which would have to be added to the radioactive iodide to reduce the adsorption of the active material on the mud to insignificant levels. The iodine 131 as supplied by the Radio-Chemical Centre, Amersham, United Kingdom, is carrier free.

Following their investigations into the occurrence of iodine in some Japanese lakes, Sugawara et al concluded that suspended floccula, (particularly hydroxides of Fe^{3+} and Al^{3+}) adsorb iodide ions under aerobic conditions, then sink to the bottom of the lake and release the entrained iodine under anaerobic conditions. Although this particular mechanism may not apply to the water of the Maitland pond, it was still important to know the adsorption of iodine from all possible causes.

By determining the minimum concentration of iodine 131 in water which could be detected by our instruments and relating this to the total volume of the pond, it was decided to use approximately 500 millicuries of iodine in the test.

2. EXPERIMENTAL

The procedure used for measuring the adsorption of the iodine 131 on the mud was as follows :-

A one gram sample of mud was added to 50 mls. of water containing a known activity of I^{131} and varying known amounts of potassium iodide carrier. The mud supplied from the bottom of the lake was far from homogeneous and no attempt was made to select uniform samples for use in these tests.

The mud was left in contact with the iodine 131 solution with frequent stirring and once each day, after vigorous stirring, a 5 ml. sample of the suspension was withdrawn and centrifuged. One ml. (or a larger volume, depending on the activity), of the supernatant was then transferred to an aluminium planchet, evaporated to dryness and counted with an end-window Geiger counter, mounted in a lead castle.

This procedure was repeated daily for a period of up to eight days. From the initial reading of the activity of the least adsorbed sample, the decay curve for iodine 131 (half life 8.04 days), was drawn. Subsequent experimental points falling below this line indicated decreased activity in the supernatant and hence adsorption of the iodine by the mud.

The carrier concentration was expressed as a ratio of weight of carrier to activity of iodine 131, referred to the start of the experiment. During the course of the run, as the iodine decayed, this ratio, of course, increased, but the initial ratio is quoted in all the results.

3. RESULTS

Various laboratory runs were made under different conditions and using different amounts of carrier.

One series of experiments carried out with demineralised water showed virtually no difference from lake water as far as adsorption was concerned.

It was also of interest to know the amount of adsorption on the glass walls of the apparatus used to contain the active solutions.

The results shown in Fig. 1 are typical of the results obtained throughout this work and are reported in detail as shown :-

Curve A	1 g.mud, no carrier)
Curve B	no mud, no carrier)plus 10 mls. I.131 soln.
Curve C	no mud, 2 mg. carrier) and 40 mls. lake water
Curve D	1 g. mud, 2 mg. carrier)

At the start of this experiment, the iodine 131 solution contained an activity of 0.055 μ c/ml.

Using 2 mg. carrier, the carrier concentration was thus

$$\frac{2}{0.55} = 3.6 \text{ g.KI/mc I.131}$$

Curve B of Fig. 1 shows that, in the absence of carrier, there is appreciable adsorption of iodine 131 by the glass walls of the containing vessel over a period of 8 days.

Curve C shows that, in the presence of carrier of the above concentration, the adsorption of the I.131 on the walls of the vessel is entirely suppressed.

Curve A indicates the extent of the total adsorption due to the walls of the containing vessel and the mud in the absence of carrier and from this it is seen that the adsorption due to the mud alone is appreciable.

Curve D shows that in the presence of this carrier concentration (3.6 g.KI/mc I.131) there is no adsorption of iodine on this particular mud sample.

To obtain some idea of the relative efficiency of various carrier concentrations in preventing adsorption on the beaker walls and the mud samples, the percentage adsorption after a period of eight days was plotted against the initial carrier concentration for most of the runs carried out - see fig. 2.

The percentage adsorption was obtained by dividing the difference between the theoretical (as indicated by the decay curve) and experimental activities by the theoretical activity and expressing the result as a percentage.

4. DISCUSSION

There is a very large scatter shown by the points in figure 2. It is considered that this is largely due to the heterogeneity of the mud samples. As mentioned earlier, the samples consisted of a mixture of sand and fine mud of varying proportions and because of the difference in specific surfaces of the two constituents, it is to be expected that there would also be a large difference in the adsorptive properties of the two.

Variations in the surface of the glass of the apparatus used in the experimental work (due to previous history, etc), could also account for some differences in the combined adsorption of the glass and mud.

It is also difficult to correlate accurately the results obtained from a laboratory investigation of this nature and the results to be expected from a large scale field test. The weight of the mud samples used in this work (1 gram) was purely arbitrary and the ratio of the surface area of the sample to the volume of water used in the laboratory experiment could be very different to this ratio as applied to the field conditions.

However, during the laboratory experiments, attempts were made to make the conditions for adsorption as favourable as possible by frequently stirring the mud and active solution and it is considered that the overall conditions in the laboratory experiment were at least as favourable and probably very much more favourable to adsorption than the conditions under which the field test was performed. In the test the tracer was introduced in the warm surface water and only very slowly penetrated towards the mud.

Another point to be borne in mind is that even if there were appreciable adsorption on any finely divided mud which was suspended in the water of the lake, provided this fine material stayed in suspension, it would not affect the efficiency of the iodine 131 as a tracer.

For the reasons listed above, it was decided that a carrier concentration of 20 g potassium iodide per millicurie of iodine 131 would, with a considerable safety margin, be effective in reducing the mud adsorption to a very small level. The total activity of iodine 131 used in the field test was approximately 470 millicuries and the amount of potassium iodide carrier added was 20 lbs.

5. REFERENCE

1. Sugawara, Kojama and Terada.

"co-precipitation of Iodide Ions by some Metallic Oxides with special reference to Iodide Accumulation in Bottom Water Layers and Interstitial Water of Muds in some Japanese Lakes."

U.N.E.S.C.O. International Conference on Radio-Isotopes in Scientific Research - Paris, 1957.

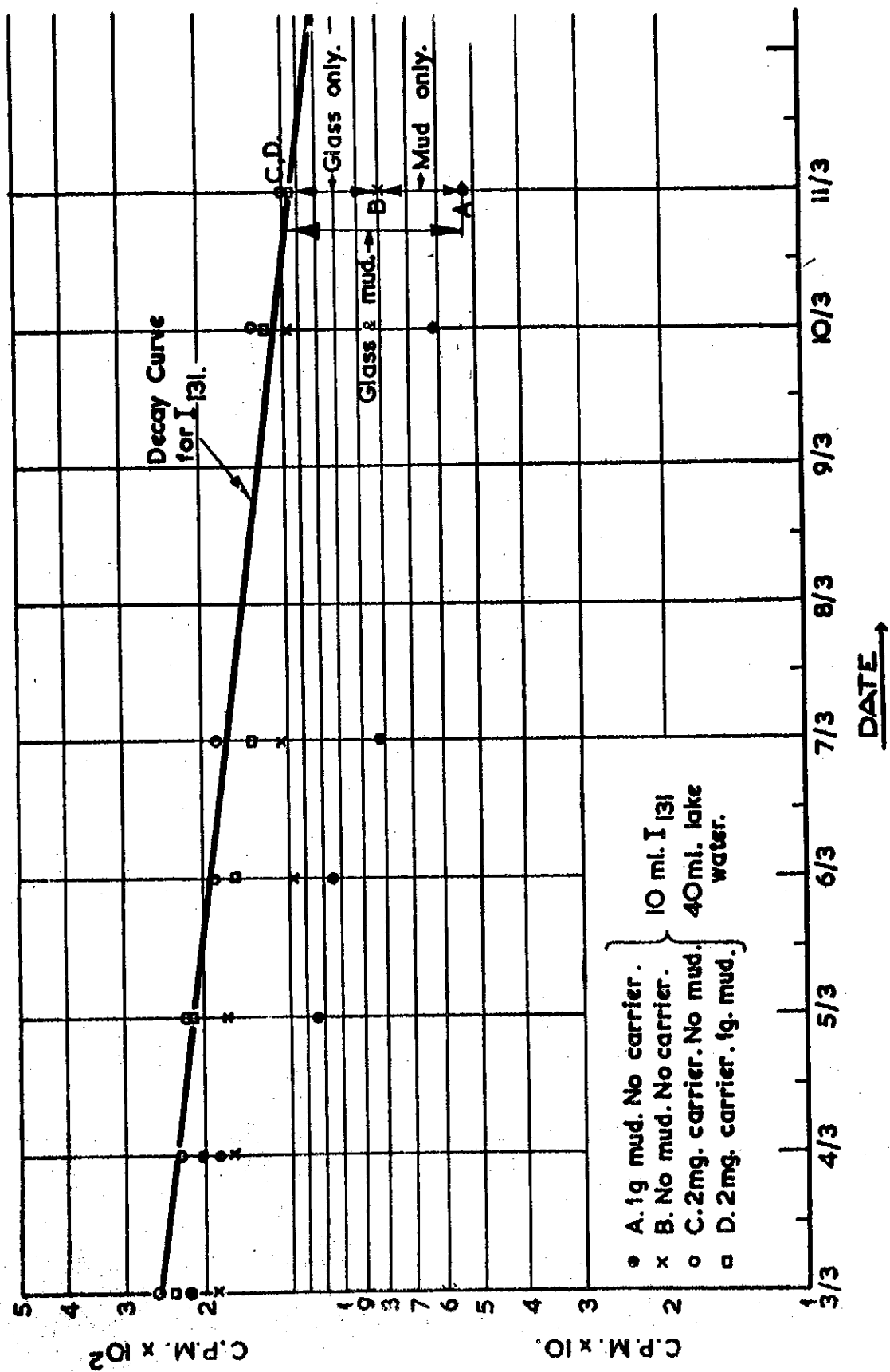


Fig.1. Adsorption of Iodine I_{131} on Mud.

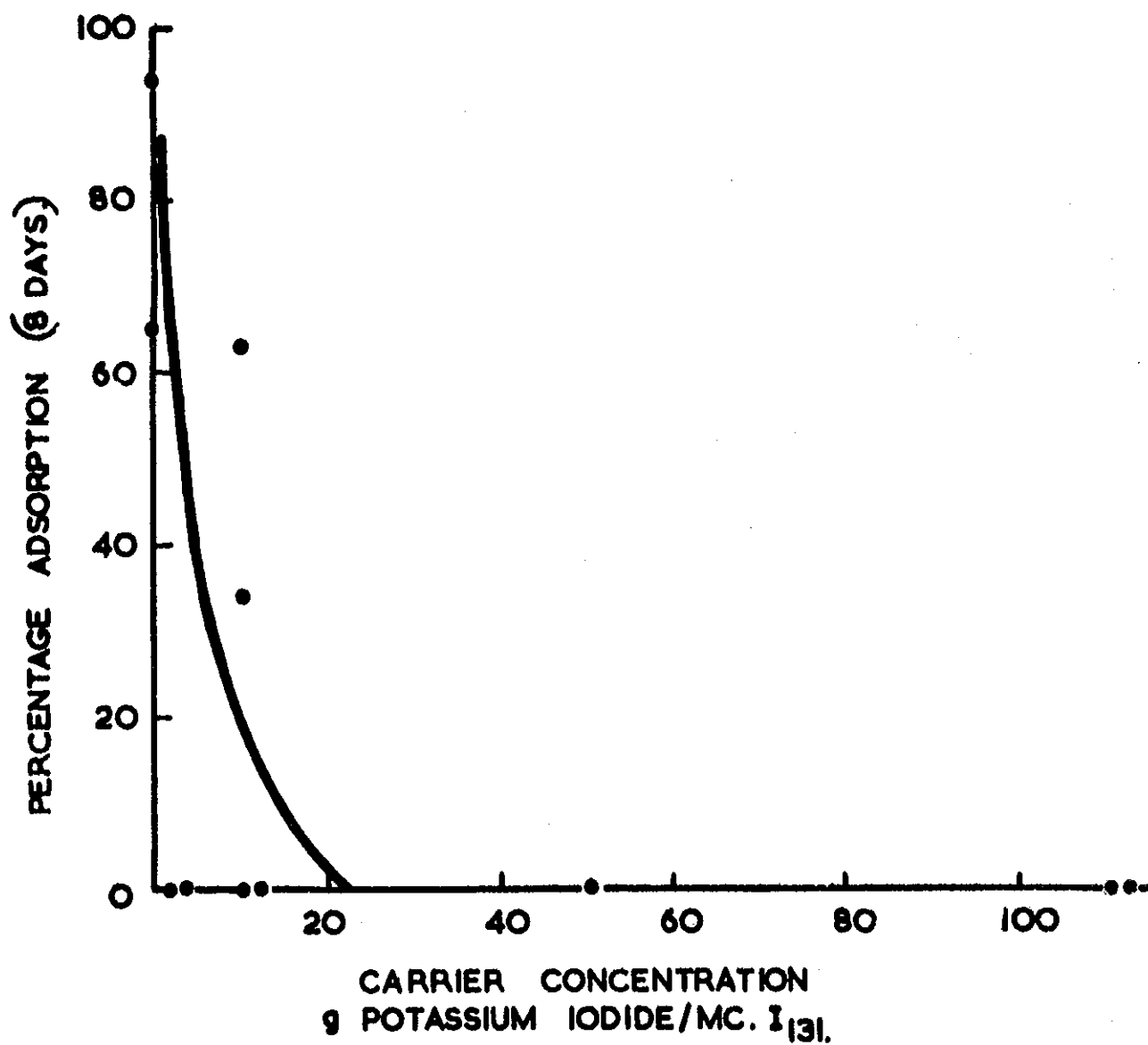


Fig. 2. Percentage Adsorption vs. Carrier Concentration.