CXXVII. THE TOXICITY TO TROUT OF POTASSIUM CYANIDE AND *p*-CRESOL IN WATER CONTAINING DIFFERENT CONCENTRATIONS OF DISSOLVED OXYGEN.

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THE estuary of the River Tees receives sewage and industrial effluents of various kinds. As a result it contains substances directly poisonous to fish and is only partially saturated with dissolved oxygen. It has been found [1932] that the death of migratory Salmonidae which occurs every year is mainly due to the presence of cyanide, and that samples of the estuary water are rendered innocuous when the cyanide is removed from them. It is of interest therefore to know whether the toxicity of cyanide in solution increases with a decrease in the quantity of dissolved oxygen. Although in rivers flowing through industrial areas direct poisons are frequently found in waters of low oxygen content, no reference to the joint effect of these factors on the toxicity of the water has been found in the literature.

EXPERIMENTAL.

A supply of deoxygenated water was obtained by a method similar to that described by Shelford [1918]. Water was boiled for some hours in open vessels, and cooled in completely full, airtight, galvanised iron cans. When cold, carbon dioxide was bubbled through the water until the p_H fell to approximately 7.0. By this method water containing a concentration of oxygen equivalent to about 5 % of the saturation value could be obtained. For experimental purposes this water was brought to the required oxygen concentration either by aeration or by mixing with tap-water. It was found by a series of experiments that the toxicities of cyanide solutions made up with boiled and re-aerated water and with tap-water were the same. Solutions containing 0.62 g. *p*-cresol or potassium cyanide equivalent to 0.011 g. CN per 100 litres were made up with water containing different concentrations of dissolved oxygen, and the toxicities to rainbow trout (*Salmo irideus* Gibb.) were determined. The experiments with low concentrations of oxygen were carried out in stoppered carboys containing about 20 litres of solution, but at higher oxygen concentrations open pots containing 30 litres were employed. In the former case one or two fish were used for each experiment, and in the latter usually five. The oxygen concentration did not vary appreciably during the period of any experiment. When exposed to lethal solutions of a poison a rainbow trout eventually loses its equilibrium and turns over helplessly on its back. In these experiments, the interval between first exposure to the solution and final overturning time has been taken as a measure of toxicity: the toxicity, following the practice of other workers, has been expressed as $100/T$, where T is the overturning time in minutes.

Fig. 1. The toxicity to rainbow trout of potassium cyanide in solutions of different dissolved oxygen concentrations.

Fig. 2. The toxicity to rainbow trout of *p*-cresol in solutions of different dissolved oxygen concentrations.

RESULTS.

The relation between the toxicity of a cyanide solution and the oxygen concentration is shown in Fig. 1. For each 10 % rise in oxygen concentration, 20 determinations of toxicity were made, and in each group the oxygen values and toxicities have been averaged to give a point on the graph. At low oxygen concentrations the toxicity of the cyanide solutions increased rapidly with decrease in oxygen concentration.

The general shape of the curve showing the relation between the dissolved oxygen concentration and the toxicity of a solution of *p*-cresol (Fig. 2) is similar to that for potassium cyanide. The curve for *p*-cresol is based on 8 determinations of toxicity for each 10 % rise in oxygen concentration. In both graphs the scattering of the points may be attributed to the relatively large variability in the susceptibility of individual fish to poisons.

Some preliminary observations have shown that at 4.5° rainbow trout are apparently unharmed after exposure for 68 hours to water containing dissolved oxygen to the extent of only 25 % of the saturation value. In another experiment [Southgate, 1933] trout remained in a healthy condition for 5 weeks at 14.5 to 17° in water in which the oxygen content varied from 37 to 58 % of saturation. In none of the solutions used in the present investigation was the oxygen deficiency itself sufficiently great to cause the fish to overturn during the period of the experiments. It is clear that in polluted waters whilst the oxygen deficiency may not of itself be sufficient to cause the death of fish, it will greatly increase the toxicity of directly poisonous substances which may be present.

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