BACTERIA IN SEWER AIR.

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The idea of the connection between sewer gas and disease dates back to the days when the cause of the infectious maladies was still unknown. Mysterious miasmatic influences were naturally enough supposed to accompany the foul odours of decomposing organic matter. When it was proved that the contagious and infectious diseases are due to the presence of microscopic plant and animal parasites, the case against sewer gas seemed less convincing.

Nageli and many other bacteriologists showed that under ordinary conditions germs adhere strongly to moist surfaces, and are not easily given off from liquids into the adjacent air. Sir Edward Frankland in England, and Raphael Pumpelly in this country carried out experiments which indicated that chemicals in solution, and bacteria in suspension, might be thrown into the air from liquids by the bursting of bubbles. On this contingency the possible danger of sewer gas infection still might rest.

Actual examinations of the air in sewers, however, by Miquel in France, Petri in Germany, and Carnelley, and Haldane, Robertson and Laws and Andrewes in England, showed that sewer air as a mattter of fact contains very small numbers of bacteria, and those of types common in street air rather than in sewage. Uffelmann found the same condition in the air of a house drainage system. Carnelley and Haldane, and Laws and Andrewes isolated sewage bacteria in the immediate vicinity of points where active splashing occurred. As in the experimental studies of Frankland, Pumpelly and Dr. Abbott, of Philadelphia, there was clearly a possibility of air infection where spray was produced by some mechanical method. On the whole, however, the air of drains and sewers seemed to be of high bacterial purity, and all the observers who studied normal conditions in actual sewers concluded that the danger of bacterial infection from sewer air was remote.

These results, with the absence of any reliable evidence from the study of epidemics in favor of the transmission of germs by sewer air, has led sanitarians in Germany and the United States to agree with practical unanimity that the danger of such transmission may be disregarded. In England, on the other hand, a large number, probably a majority, of sanitary experts have failed to be convinced, and have clung to the opinion that under some conditions the carriage of disease bacteria by sewer air is a practical possibility.

A little over a year ago, at the request of the National Association of Master Plumbers, I made some experiments on this problem, upon which no practical investigations had been conducted for over ten years. I used an experimental stack of 4-in. soil pipe, 15 feet, in height, with a running trap at the bottom and an exhaust fan, for drawing up a strong current of air, at the top. Sewage was placed in the trap, sealing it partially or completely, or resting in the bottom without sealing it. Air was drawn over the sewage and wetted surfaces of the pipe, or was bubbled through the sealed trap, and the air was examined at various points in the stack above. When the air current was strong, an increase was noted in the bacterial content of the pipe air; but the increase was not striking even at high velocities, and was entirely wanting with air currents of less extreme force. Only three of the characteristic bacteria of sewage were isolated from the air in the whole series of experiments. As a result of this investigation I reported that the danger of bacterial infection from drain air was but slight.

At about the same time a series of experiments on sewer air was reported to the Royal Society of London by Major W. H. Horrocks, of the English Army Medical Corps. His results seemed at first sight to warrant widely different conclusions from those drawn by other observers; and it seemed necessary to re-examine the whole question with the greatest care.

Major Horrocks's general method consisted in the artificial infection of the lower part of natural and experimental drainage system with a peculiar bacterium, the Bacillus prodigiosus, which is not normally found in the air. He then exposed small open dishes of nutritive media (Petri plates) in the upper part of the systems. Germs carried up in the air fell on the plates grew and developed into visible colonies, and among these colonies he identified the particular form, Bacillus prodigiosus, introduced in the liquid at the bottom. By this process he detected his test organism in a pipe 9 feet above an experimental running trap into which it had been introduced, and in the air of a catch basin of the town into which he had poured it. Similar results were obtained when the lower sections of his experimental pipe system were wetted with a culture of the Bacillus prodigiosus and then dried. The dried germs were apparently detached, carried up by the air and deposited on the plates. In another series of experiments sewage infected with typhoid bacillus, or with Bacillus prodigiosus, was allowed to flow, quietly and without splashing, through a horizontal pipe to which a vertical pipe was connected at an intermediate point. Plates exposed in the vertical pipe showed colonies of the specific bacteria introduced below, even at a height of 11 feet 9 inches, above the liquid. Again, emulsions of Bacillus prodigiosus were flushed from the closets of drainage systems in actual use, and germs thus introduced were found in all parts of the systems in open connection therewith, even at a height of 50 feet above the traps. Major Horrocks, by the same method of exposing Petri plates, found Bacillus coli, the characteristic organism of sewage, in a house drain and in the main sewer of the town. Finally he passed the feces of a typhoid patient suspended in water through a half-S trap, and found the typhoid organism on plates in a vertical pipe above it at a height of 3 feet 6 inches above the liquid.

Major Horrocks's report, and still more recent series of confirmatory experiments by Dr. F. W. Andrewes of London naturally excited the deepest interest among sanitarians. In many quarters the old suspicions of sewer air were revived in almost their full force.

The Journal of the American Medical Association, for example, said in commenting upon Horrocks's work: "We may still have to look to sewer emanations as the occasional cause of mysterious outbreaks of disease." The other sanitarians maintained a more conservative attitude, and waited further evidence before abandoning their previous conclusions. The matter stood about as follows: On the one hand, Horrocks had shown that specific bacteria, present in traps and drains, could get into the air above by splashing, by the bursting of bubbles, and even in some experiments from the surface of liquids apparently in quiet motion; he detected such bacteria by the plate method in the air of ventilating pipes at considerable distances (once at 50 feet.) above the infected liquid. On the other hand, Miquel, Petri, Uffelmann, Carnelley and Haldane, Laws and Andrewes, and others, had shown that the number of bacteria actually present in the air of sewers and house drains is extremely small, and that those present are generally air forms and not sewage forms. Furthermore, reliable evidence of the spread of infectious disease by sewer air is wholly lacking. In the inconsistency of the two sorts of evidence required in explanation; and, after presenting the facts to the Sanitary Committee of the National Association of Master Plumbers, I was commissioned by them to attempt the clearing up of the apparent contradiction.

I first attempted to repeat as closely as possible one of Horrocks's simpler experiments. I examined the air of a boat chamber on one of the main sewers of the city of Boston, as Horrocks had done in the sewers of Gibraltar. I found colon bacilli, the characteristic sewage organism,

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