THE TREATMENT OF WASTE WATER WITH FERROUS SULPHATE AND LIME.

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The treatment with ferrous sulphate and lime of the waste water from the cookhouse and ablution shed of the Army School of Hygiene has now been in operation for ten months.

The general principle of this method is to adjust the pH value of the waste water with lime to about ten, after it has been dosed with ferrous sulphate. A heavy floc is immediately formed, which quickly settles down carrying with it all the suspended and colloidal matter in the water, leaving the water perfectly clear.

To allow this sedimentation to take place provision must be made for storing the waste water for a few hours while it is being treated. There must also be some means of running off the clear effluent and sludge after treatment.

It has been found in practice that the chemical treatment is very simple to carry out. A man who has seen it done once finds no difficulty in carrying out the treatment himself. The duty of treating the waste water at the School by this method has been handed over from one man to another without any supervision. No man has ever yet failed to get good results.

The only point the man has to remember is to add the ferrous sulphate first and mix it well with the water. Then add the lime in the form of cream of lime until a heavy dark green floc forms, stirring the water well the whole time. The change is so striking that there is no difficulty in deciding when the correct pH value has been reached, or in other words when the correct amount of lime has been added.

Depending on the nature of the waste water, the quantity of ferrous sulphate required will vary from three to eleven ounces for every hundred gallons, but the quantity required for a waste water from the same source every day is fairly constant. Once the approximate amount required to obtain a good result has been ascertained, the same quantity is added daily as a matter of routine. The quantity can be checked occasionally.

The amount of lime varies daily, but as it is simply poured in as a cream of lime until the desired result is obtained, there is no need to weigh out any definite quantity. If there is any left over, it can be used the next time the treatment is carried out.

As already stated, the optimum pH value is about ten, but it has been found in the laboratory, and also in practice, that if by accident too much

lime is added little harm results. The effluent is slightly cloudy, but this cloudiness can be got rid of by giving the waste water an extra stir. After the first few weeks, therefore, it has been the rule for the man in charge of the treatment to give the waste water an extra stir about half an hour after the original dosing. Since then, the effluent has always been perfectly clear, even if too much lime has been added by accident.

The Sludge.

Before this method was tried out on a large scale, it was thought that, however good the results might be, the disposal of the sludge would present difficulties. The exact opposite has been the case. The disposal of the sludge has been surprisingly easy. When run off, the sludge is dark green and contains between 95 to 98 per cent of water. On exposure to air, it turns a light brown. It has no smell and does not attract flies. If run on to the ground or into a shallow trench, it loses this moisture and quickly becomes semi-solid in consistency. Although the state of the weather naturally affects the rate of drying, the loss of moisture takes place even in wet weather as the following figures show. This actual sludge was run into a shallow trench.

	Percentage of moisture
Sludge on being run off	97·6
After 1st week with 2·4 in. of rain during week	73·5
,, 2nd ,, 1·6 in. ,, ,,	64·9
,, 3rd ,, 0·6 in. ,, ,,	56·4
,, 4th ,, 0·2 in. ,, ,,	41·5
,, 5th ,, 0·0 in. ,, ,,	35·7
,, 6th ,, 0·2 in. ,, ,,	35·9
,, 7th ,, 0·8 in. ,, ,,	35·6

These determinations were made in the spring of 1935, but it was found during the preceding winter that, no matter how wet the weather was, the sludge always lost about 50 per cent of its moisture in a few weeks. After that the figure was stationary and the sludge had the consistency of cream cheese.

With the coming of the hot dry weather in July and August, 1935, the moisture quickly fell to below 1 per cent and the sludge turned into powder.

Rain never affected its consistency, because having once lost its moisture it did not absorb water again.

The sludge had been put to various uses as an experiment. Some of these would not have been tried out if it had been known that the sludge so easily turned into powder in dry weather.

The sludge was put down on a path in the hope that it would kill the weeds. It powdered too much, however, to make a good surface and did not prevent weeds from growing.

Broad beans and peas were planted in trenches filled with the sludge. A fair crop was obtained but it could not be recommended as a fertilizer.

A suggestion was made that it would make a good top dressing for lawns. It was spread over a patch of grass. All trace of the sludge soon disappeared, but the grass showed no signs of having benefited or suffered by this treatment.

It cannot be claimed, therefore, that any use has been found for the sludge, but the above experiments show how innocuous it is and that it gives rise to no nuisance.

Sludge that had been trenched was dug up after three months. All that could be found was apparently soil, brown in colour. The sludge had simply dried, and after the ground has been dug over a few times there will be no trace of it.

The quantity of sludge to be dealt with is small. At first sight, owing to its flocculent nature, its bulk seems large, but as over 95 per cent is water, the final amount is quite small. In fact there has been a shortage of it at times for carrying out various experiments. The small quantity to be dealt with is natural when one remembers that the sludge is only suspended and colloidal matter in dirty water, with the addition of a few ounces of ferrous sulphate and lime.

The Effluent.

The effluent has always been clear with no smell. Incubation tests on the waste water and effluent have been carried out on eight different occasions. Putrefaction, accompanied by an offensive odour, has always occurred with the untreated waste water after two days' incubation at 37° C. but no offensive odour has ever occurred on incubating the effluent.

The reduction of suspended solids on four different occasions is shown below in parts per 100,000 :—

Waste water		Effluent
70	..	0·8
44	..	0·8
65	..	0·4
115	..	0·8

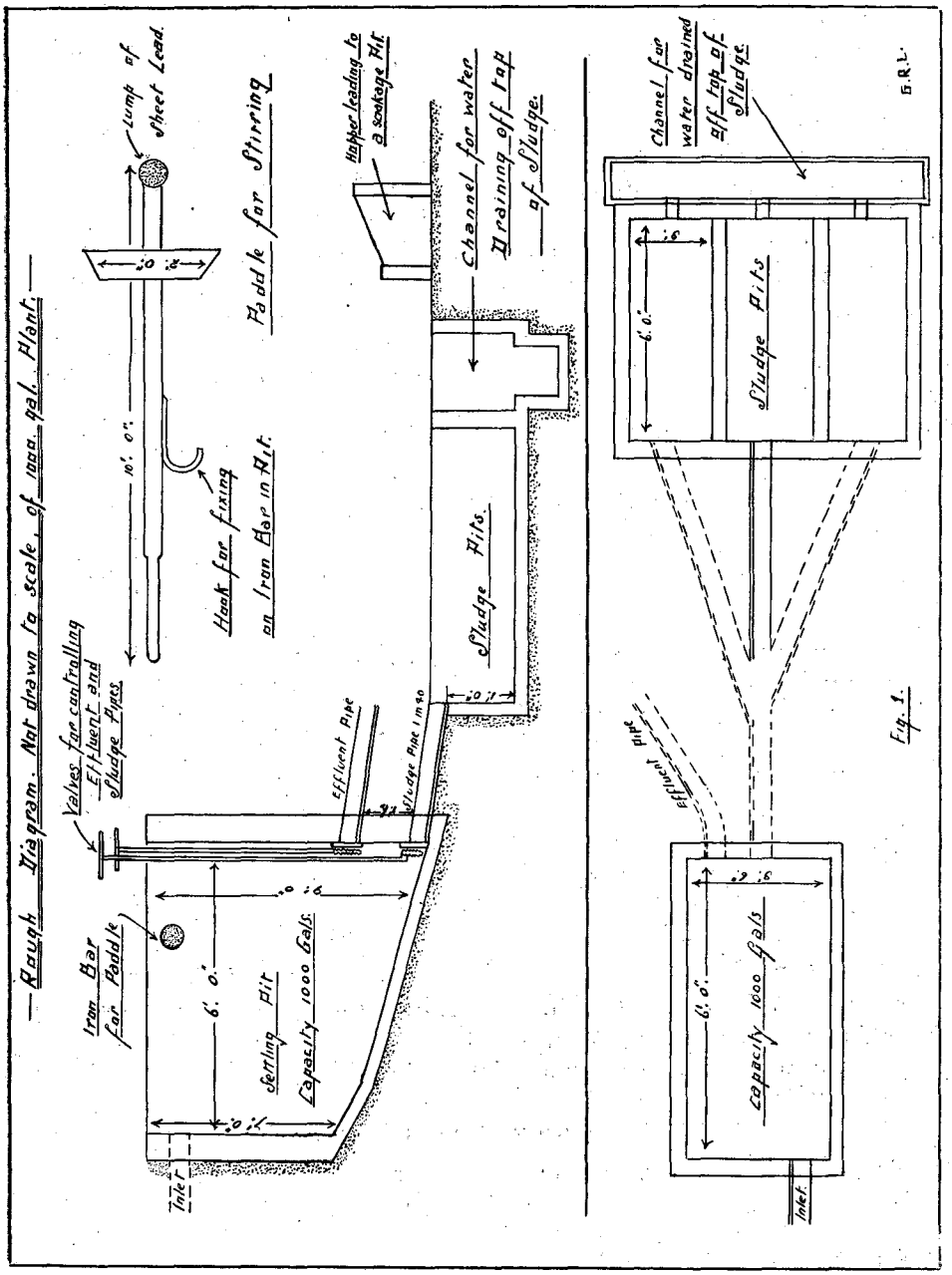
Apart from the increase in hardness, there seems to be no reason why the effluent, after chlorination, should not be used again for ablution purposes, if there was a shortage of water.

Details of Plants Used.

Two plants have been tried out at the Army School of Hygiene. One dealing with a thousand gallons of waste water at a time and the other with about fifty gallons.

Mistakes were naturally made in the construction of these plants as one had only laboratory results to work on. They will be pointed out so that they can be avoided by anyone who may wish to try the method.

(1) *Thousand-gallon Plant.*—The waste water from the kitchen, ablution shed, regimental institute and dining hall at the Army School of



Hygiene has in the past passed through a series of concrete pits fitted with baffle plates. One of these, which has a capacity of about five hundred

gallons, has been deepened until its capacity is now a thousand gallons. Its dimensions are 6 feet long, 3½ feet broad and 8 to 9 feet deep. At the bottom there is a four-inch channel with benchings sloping into it. This channel can be closed by a valve and is used for running off the sludge. Thirteen inches above this channel is a four-inch pipe, controlled by another valve, to run off the clear effluent. The capacity of the pit between these two outlets is forty-five gallons.

The pit is filled by the waste water running into it through a four-inch pipe, after having passed through a strainer to remove gross particles. The waste water can be shut off when the pit is full. A diagram of the pit is shown in fig. 1.

A wooden paddle which fits on to an iron bar, running across the top of the pit, is provided for stirring the contents of the pit.

When the pit is full the waste water is shut off and five pounds of ferrous sulphate, previously dissolved in a bucket of water, are poured into the pit. The contents are well stirred with the wooden paddle. Cream of lime is then poured in gradually, the stirring being continued, until a heavy green floc forms and the water clears. After a good stir the contents of the pit are left for half an hour, when they are given a further good mixing.

The floc is then allowed to settle down and the clear effluent can be run off any time after five hours.

A slight scum may form on top of the water during sedimentation but gives no trouble. When the clear effluent has been run off, this scum comes down on to the sludge and is run off with it.

The mistakes made in the construction of this pit were as follows :—

(1) The pit was made too deep and sedimentation therefore took longer than it would have done if its square area had been increased and its depth decreased. A pit already in existence was responsible for the present shape.

(2) The valves controlling the sludge channel and effluent outflow were placed on the inside of the pit. As a result, the floc collected on the effluent valve and the first four or five gallons of the effluent contained sludge. If the valves had been placed on the outside of the pit, this would not have occurred. It is of course obvious, now, that there should be no projections on the sides of the pit on to which the floc can settle.

(3) The paddle gave good results but is primitive. A better type would probably be one like a propeller and worked by turning a handle.

The clear effluent is run into a ditch which finally discharges it into the Basingstoke Canal.

The sludge is run off into one of three shallow concrete pits, measuring 1 foot deep, 3 feet broad, and 6 feet long. These are well shown in the photograph, fig. 2.

At one end of these shallow pits are holes at various levels so that any water which appears on top of the sludge as it packs down can be drained

off into a concrete channel. The water, which collects in this channel, is bailed out into a hopper leading to a soakage pit.

The pits are taken into use in rotation, each pit taking the sludge of about three emptyings of the treatment tank. The sludge is allowed to dry in these pits and is then transferred to the ground just beyond them.

These concrete sludge pits would have been quite unnecessary if the thousand gallon treatment tank had not been made so deep, as the sludge could have been run straight into the shallow pits and dug in the ground, where it would have dried much quicker. But the treatment tank having been made so deep it was not possible to use drying pits dug in the ground owing to the level of the subsoil water.

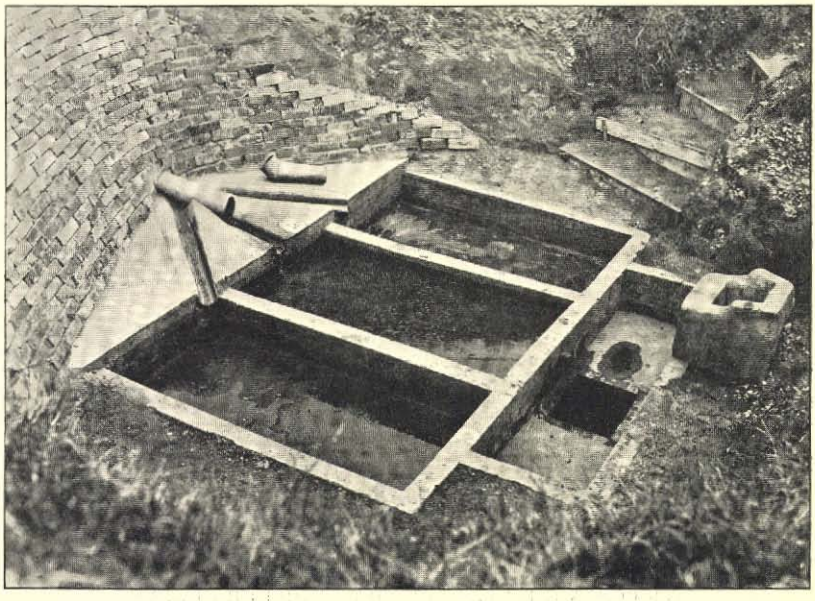


FIG. 2.—General view of sludge pits. By the use of a loose piece of tin piping, the sludge can be run into each pit in turn. The water, which drains off the top of the sludge, is bailed into the hopper shown on the right.

(2) *Fifty-gallon Plant.*—The other plant which has been tried out is intended for use in camps where smaller quantities of waste water might have to be dealt with. A barrel holding fifty-six gallons is placed on a stand outside the ablution shed. A tap is fitted into it, seven inches from the bottom. The men empty the contents of their wash bowls into the tub. When the tub is full, a solution of four ounces of ferrous sulphate is poured into the barrel and the contents stirred with a stick. Cream of lime is then added until the desired result is obtained. After standing for one hour, the tap is turned on and the clear water is run into a channel dug in the ground where it quickly soaks away. The channel is 1 foot deep, 9 inches broad, and 6 yards long.

The sludge is tipped out of the barrel into a shallow pit six inches deep by means of rope handles fitted to the barrel (*see* fig. 3).

It is considered that two barrels or similar receptacles could be set up alongside an ablution bench ; into these the waste water could be emptied and then treated as described.

FIG. 3.—Barrel outside ablution shed showing channel for effluent and shallow pit on left into which sludge is emptied.

COST OF METHOD.

Ferrous sulphate is listed in the Vocabulary of Army Ordnance Stores as " Iron Sulphate, Commercial, green copperas, cwt. £0 6s. 7d."

At this price, using 3 to 11 ounces per 100 gallons, the cost is 0·13 to 0·48 of a penny for every 100 gallons treated. The routine quantity added to the waste water at the School is 8 ounces per 100 gallons, costing 0·33 of a penny. It is only fair to state that the waste water used for these experiments was distinctly foul.

The quantity of lime used of course varies, but it has seldom exceeded the quantity of ferrous sulphate used. Its cost is less than 2s. 6d. a cwt.

If these figures are compared with the use of chloride of lime which is recommended in the Official History of the War, Medical Services, Hygiene of the War, Vol. I, page 383, it will be seen how cheap it is.

The quantity of chloride of lime required is stated to be 0·3 to 1·0 per cent, or from 3 to 10 pounds per 100 gallons. The cost of chloride of lime is £1 1s. per hundredweight so that the cost of treating 100 gallons would be 6·7 pence to 22·4 pence.

So far as India is concerned, information has been received from a well-known firm that the cost of ferrous sulphate in Bombay is approximately 6s. 6d. per hundredweight.

There does not seem to be therefore any objection to the method on the question of cost.

Conclusions.

If waste water is treated with ferrous sulphate and the pH value adjusted by the addition of lime as described, a perfectly clear effluent is obtained.

The treatment is very simple to carry out and the plant required for small installations can be easily improvised.

It can be used to deal with either large or small quantities of waste water.

The sludge does not smell or attract flies. It gives rise to no nuisance.

The process is comparatively cheap and there is no difficulty in obtaining the chemicals required as they are already articles of supply.

In the event of a shortage of water, the effluent could be chlorinated and used again.

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