OIL AND WATER
ABSORPTION CAPACITY

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OIL & WATER ABSORPTION CAPACITY

Report Prepared By the Sydney Environmental and Soil Laboratory and Australian Government Analytical Laboratory Three experiments were performed to assess the behavior of SpillFix Industrial Organic Absorbent as a pollution control/containment medium.

1. Oil Absorption Capacity

In this experiment used motor oil was used to check the maximum amount of oil that SpillFix Industrial Organic Absorbent can hold. This is important when making recommendations for its use to soak up spills. The Air Filled Porosity/Water Holding Capacity (AFP/WHC) method and apparatus of AS 3743 was used.

Firstly the WHC of the particular batch of SpillFix Industrial Organic Absorbent was measured using the conventional AS 3743 methodology. It found that 710 mls of SpillFix Industrial Organic Absorbent (the volume of an AFP/WHC core) would hold about 400mls of water against gravity or a WHC of 56.3%. Note that this occurs with a suction height of 12 cm (ie 12cm deep SpillFix Industrial Organic Absorbent).

In the oil experiment 4 treatments were set up. Firstly 710 mls of SpillFix Industrial Organic Absorbent was measured into each of 4 large trays. To each of the treatment trays 100mls, 200mls, 400mls, and 800mls of oil was poured and thoroughly mixed in. SpillFix Industrial Organic Absorbent plus oil was then placed back into a 710ml AFP core which rested on a rack to allow oil to drain. The cores were left over the weekend (60 hours) for oil to drain and then the oil draining into the tray was weighed. The density of oil had previously been measured at 0.85g/ml allowing this to be converted to a volume of oil. Results are expressed in Table 1.

Table 1. Oil Holding Capacity of SpillFix Industrial Organic Absorbent.

	100mls oil	200mls oil	400mls oil	800mls oil
Oil drained after 60 hours mls	0.0	0.0	75	396
Oil retained or held mls	100	200	325	404
Oil holding capacity as % v/v	14.1	28.2	45.8	56.9

Discussion and Conclusions: These results appear to show an unexpected “enhancement” effect, i.e. that the more oil that is added the more will be held. Plotting the results on a graph (see appendix) demonstrates that there is actually an asymptote to this, i.e. that the maximum oil holding ability levels off at about 405 mls /710mls SpillFix Industrial Organic Absorbent or 57%.

One explanation for this “enhancement effect” is that the material swells in the presence of oil quite noticeably and this would increase its oil holding ability. An interesting observation is that the oil holding capacity is not dissimilar to the water holding capacity. A fair conclusion to allow for all situations would be that the material will hold a minimum of 40% of its volume of oil in all conceivable circumstances. To claim 50% would be reasonable in nearly every instance.

SEPARATION OF OIL/WATER MIXTURES

A potentially important application is to use the material to remove oil from the surface of waters or to separate by filtration oil from water.

In this experiment three AFP/WHC cores were filled with 710mls of SpillFix Industrial Organic Absorbent. These were then emptied into each of three tough plastic bags and emulsified oil/water mixtures were added. This was achieved by rapidly shaking 500mls water with each of 100, 200, and 400mls of oil and rapidly pouring the milky emulsion into the plastic bag before the oil and water separated again. Contents of the bag were stirred and shaken thoroughly and left for about one hour to full soak up their contents.

Contents were then emptied carefully back into the three AFP cores and left 60 hours to thoroughly drain. The volumes of water and oil draining from the cores was then measured. Results are in Table 2.

Table 2. Oil/Water separation results.

Treatment	100mls oil – 500mls water	200mls oil – 500mls water	400mls oil – 500mls water
Total Volume added	600	700	900
Water Drained mls	235	300	345
Oil Drained mls	0	25.6	170
Water held mls and (as % of added) - A	265 (53%)	200 (40%)	155 (31%)
Oil held mls and (as % of added) - B	100 (100%)	174.4 (87.2%)	230 (57.5%)
Total Volume held	365	374.4	385
Fluid holding capacity %	51.4	52.7	54.2
Oil to water partitioning ratio B/A	1.89	2.18	1.85

Discussion and Conclusions: The "enhancement effect" of increasing fluid holding capacity with increasing oil addition is also evidence here but to a smaller extent than with adding oil alone. Also, swelling was again seen with added oil.

The interesting effect also is the "partitioning effect" that is, in the presence of an oil/water mixture the SpillFix Industrial Organic Absorbent preferentially absorbs oil over water. The results also demonstrate a "competitive effect" in that, if the preference for oil was absolute then no matter how much water was added the oil would be

SEPARATION OF OIL/WATER MIXTURES cont.

exclusively held. This is not the case and clearly, from the first experiment the SpillFix Industrial Organic Absorbent should have been able to hold between 300 and up to 400mls of oil which it cannot do in the presence of excess water. The net result is that while oil is preferred over water increasing amounts of water have an adverse effect on oil retention.

A rough "partitioning ratio" can be estimated from the proportion of oil added and held vs the proportion of water added and held. These are given in the final row of the table. The average of the three ratios is 1.97 or about 2. It is thus true to say that SpillFix Industrial Organic Absorbent shows twice the affinity for oil as for water.

This can be translated into a recommendation. The total fluid holding capacity is about say 52%. If presented with say 2 liters of 40% oil/ 60% water emulsion 1 liter of SpillFix Industrial Organic Absorbent could be predicted to absorb 520mls of the mixture and of this 520 mls twice as much will be oil as water or about 346 mls oil and 173mls water. Thus if the 2 liters was 40% oil or 800mls of oil then 1 liter of SpillFix Industrial Organic Absorbent would remove 43% of the oil.

How much SpillFix Industrial Organic Absorbent is required to remove all the oil is a more difficult calculation. Actually a 40/60 oil water emulsion is higher in oil than most real life situations. Take a 5% oil film on 95% water, say 10 liters of it or 500mls oil on 9.5litres water. How much SpillFix Industrial Organic Absorbent is required to remove all the oil but leave as much water as possible?

Assuming the total fluid holding capacity of 52% is composed of 2/3 oil and 1/3 water (partitioning coefficient of 2) then while holding 500mls oil the SpillFix Industrial Organic Absorbent must also hold 250mls water or a total fluid capacity of 750 mls. Divide this by 0.52 (the fluid holding capacity) we get 1442 mls of SpillFix Industrial Organic Absorbent. This should remove all the oil and only 250mls of water. A check of this was made adding 1500mls of SpillFix Industrial Organic Absorbent to a bucket containing 9.5 liters water and 500mls of oil. This was then stirred for a few minutes every hour for 3 hours. Upon removal of the floating SpillFix Industrial Organic Absorbent very little oil (less than 10mls) was left.

A general recommendation would be that the maximum oil removal can be obtained by adding three times as much SpillFix Industrial Organic Absorbent as the anticipated oil volume. For optimum and complete removal this could be increased to say a factor of four. ie to completely clean up 1 liter of oil off water will require 3-4 liters of SpillFix Industrial Organic Absorbent.

LANDFILL LEACHATE TESTS

Landfill leachate occurs as a result of water flowing through waste landfills' especially uncontrolled landfills which are not caped properly. It is common to find soluble zinc, phenols, cyanide, and ammonium in landfill leachates.

Methodology: A mock landfill leachate solution was made to the following approximate specification In each of five 1 liter beakers 500mls of leachate solution was added. To each beaker a series of SpillFix Industrial Organic Absorbent additives were made to give the following experimental design:

Zinc	10 mg/l using zinc acetate
Phenol	50 mg/l
Cyanide	20mg/l using potassium cyanide
Ammonium	100 mg/l using ammonium chloride

Treatment	mls leachate	mls SpillFix - IA
0	500	0
1	500	100
2	500	200
3	500	400
4	500	600

Beakers were stirred occasionally over 4 hours then filtered to obtain test solution. Test solutions were then analyzed for the four contaminant components. Australian Government Analytical Laboratory measured Cyanide and phenol, Sydney Environmental and Soil Laboratory measured ammonium and zinc by routine methods. The following results were obtained:

Treatment mls MIA/500mls	Zinc mg/l	Phenol mg/l	Cyanide mg/l	Ammonium mg/l
0, 0	10.3	20.0	12.0	70.6
0, 100	0.2	17.0	10.0	53.6
2, 200	< 0.2	19.0	12.0	44.4
3, 400	< 0.2	12.0	8.3	37.7
4, 600	0.2	11.0	5.9	34.3

Water held mls and (as % of added) - A	265 (53%)	200 (40%)	155 (31%)
Oil held mls and (as % of added) - B	100 (100%)	174.4 (87.2%)	230 (57.5%)

Discussion: All contaminants show a reduction upon the addition of coir to the contaminated water. The absorption of ammonium is likely to be by simple cation exchange and is characteristically non linear. The pattern shown here of diminishing ammonium removed as more SpillFix Industrial Organic Absorbent is added is very typical of an "exchange isotherm" (Sposito 1989). The relationship fundamentally says that as the concentration of ammonium external to the SpillFix Industrial Organic Absorbent exchange sites increases the absorbent will absorb (or exchange) more ammonium, or vice versa, as the ammonium level outside the exchange site decreases it will absorb less ammonium. This essentially says that can never be eliminated except at infinite SpillFix Industrial Organic Absorbent concentrations.

LANDFILL LEACHATE TESTS cont.

This is typical of exchange reactions and also phosphate removal from solution which is also concentration dependant. It is also dependant on the presence of other ions on the SpillFix Industrial Organic Absorbent and could be improved where certain ions are absent (for example potassium which is much like ammonium in size and shape).

From this experiment the best we can achieve is to approximately halve an ammonium concentration of 70mg/l by adding equal quantities of SpillFix Industrial Organic Absorbent to water. This will change depending on the initial ammonium concentration.

Zinc behaves differently to ammonium. This is essentially because Zinc is a “preferred exchange ion” and does not compete with sodium, potassium, calcium and all the other exchange ions being greatly preferred over these other ions. This is typical of all the high molecular weight (heavy) metals. It would appear that levels of zinc significantly higher than 10 ppm can be totally removed from the solution. This is likely to be the case for a range of other high molecular weights metals.

It can be calculated that the specific absorption capacity of SpillFix Industrial Organic Absorbent for zinc is at least 50.5mgZn per liter of SpillFix Industrial Organic Absorbent. As stated it could be significantly higher than this, we did not use a lower SpillFix Industrial Organic Absorbent content than 100mls. If we had used 50mls we might demonstrate greater capacity.

Phenol and cyanide show a different trend with significant reductions only occurring at 400 and 600mls/0.5l (800 to 1200 mls SpillFix Industrial Organic Absorbent per liter of water). The mechanism for removal of these contaminants is likely to be physisorbtion rather than cation exchange (both are weak acids which means they are negatively charged).

In a practical sense, once about 50/50 SpillFix Industrial Organic Absorbent and water ratio is exceeded the water has to be squeezed out of the absorbent as no free water remains.

Summary

SpillFix Industrial Organic Absorbent will absorb significant quantities of oil. It is likely that its oil, solvent, or water total holding capacity are all similar at around 55% by volume. Applying a small safety margin a simple recommendation would be that, for oil or solvent absorption in the absence of water, twice as much SpillFix Industrial Organic Absorbent as the volume of oil to be absorbed is required. If you need to soak up 1 liter of oil use 2 liters of SpillFix Industrial Organic Absorbent.

Ref: 1908-O&W

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