WATER CORPORATION

NOWERGUP SITE

MONITORING OF FLY BREEDING IN STOCKPILES OF BIOSOLID CAKE

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Prepared for:

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Cover Photo
Calliphora dubia
Calliphora albifrontalis

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1. SUMMARY

Fly breeding in stored manure has become one of the most contentious issues along the Swan Coastal Plain. Future use of biosolid cake in industry requires the development of a storage protocol that reduces fly breeding in stockpiled biosolid cake. Assessment of various management strategies requires the implementation of a monitoring program to assess fly breeding. Three stockpiles of biosolid cake were established at the Nowergup Wastewater Biosolids Facility (Swan Coastal Plain). Shade cloth covers were placed over two of the stockpiles while the third was left uncovered allowing fly access. Monitoring occurred between the 22.08.01 and the 20.06.02. Monitoring results indicated that fly breeding within the covered stockpiles of biosolid cake was negligible throughout the study. Limited fly breeding occurred throughout the colder months of August to November followed by a slight increase as seasonal conditions became more favorable. However, overall fly breeding within the uncovered stockpile was extremely low compared to the results of previous biosolid cake monitoring at this site. The establishment of the stockpile of biosolid cake coincided with the seasonal decline in fly breeding (June – October) and the stockpiles were three months old by November when fly breeding levels generally increase as a result of more favorable climatic conditions. There is some evidence that aged biosolid cake is no longer an attractive fly breeding resource, which may explain the low fly breeding observed (Nowergup Report, 2001). Further investigation is required into the stockpiling of biosolid cake in seasons of low fly activity. During this time biosolids have aged and they no longer are attractive to fly breeding in seasons of high fly breeding activity.

2. ISSUE

The Water Corporation produces approximately 40,000 wet tones of biosolid cake, 2500 tones of biosolid pellets and 6500 wet tones of lime amended biosolids annually. Biosolid cake is a stabilized, organic substance produced by wastewater treatment processes which, in most cases, can be beneficially reused (ARMCANZ, 1995). Once processed it can be used as a low-grade fertilizer in broadacre agriculture, forestry plantations and composting. The beneficial application of biosolids throughout the agricultural industry is currently being investigated. Potentially, biosolid cake offers an alternative to conventional fertilizers while recycling provides an effective avenue for disposal.

However, stockpiled biosolid cake has the potential to facilitate fly breeding and increase fly numbers (Nowergup Report, 2000a). The adverse impact of increased fly populations on livestock, outdoor workers and general community health has already been demonstrated in regional areas where excessive fly problems occur (Paulin *et al.*, 1998). Justifiably, there is concern that the transport and stockpiling of biosolid cake will enhance fly breeding, adding to the fly problem of many agricultural areas. Consequently, preliminary stockpiling of biosolid cake has undergone extensive investigation aimed at the development of a protocol to reduce fly breeding. Ongoing monitoring of fly breeding levels within stockpiles of biosolid cake is an essential aspect of all investigations.

3. OBJECTIVE

1. A preliminary study to monitor seasonal changes in fly breeding and activity in stockpiles of biosolid cake stored at the Nowergup Biosolids Facility throughout Spring, Summer and Autumn.
2. To examine the effect of time on stockpiles of biosolid cake in relation to fly breeding.

4. INTRODUCTION

Over the last nine years the fly problem on the Swan Coastal Plain has reached epidemic proportions, especially in relation to the stable fly, *Stomoxys calcitrans* (Linnaeus) and the house fly, *Musca domestica* (Linnaeus). Throughout the agricultural sector high stable fly densities represent significant economical problems and health issues. In particular, high stable fly densities represent a significant threat to livestock industries. Several studies have shown that high stable fly density and excessive biting can result in considerable economic losses. In the US beef cattle industry, stable flies account for losses of around $400 million annually (Dougherty *et al.*, 1995). Excessive fly biting and attempts by livestock to dislodge feeding stable flies can cause fatigue, stress, reduced grazing intake and weight loss. In cattle, reduced weight gain can result from infestations of as few as 20 stable flies per animal (Cook *et al.*, 1999). In dairy cattle, heavy infestations (50 flies per animal) can reduce weight gain by 25 percent and milk production by 40-60 percent (Campbell *et al.*, 2001). High numbers of stable and houseflies can disrupt the efficiency of working animals, such as dogs and horses. Higher human health risks are also associated with increased fly numbers due to the conveyance of disease carrying organisms (Gerozisis & Hadlington, 1995). At present stable fly numbers throughout the Swan Coastal Plain have reached pest proportions and have become a major issue affecting human and livestock health.

Investigative research has identified poultry manure (broiler) in crop production (vegetable, turf and strawberry) as a major source of stable fly breeding on the Swan Coastal Plain. When used as either a pre-plant or top-dressing, raw poultry manure is capable of producing in excess of 200,000 stable flies per hectare (Cook *et al.*, 1999). Predictably, fly breeding in stored manure has become one of the most contentious issues along the Swan Coastal Plain. Recent studies have demonstrated that biosolid cake acts as a fly breeding resource (Nowergup Report, 2000a). The potential transport, storage and use of biosolid cake in industry may facilitate fly breeding and contribute to excessive fly numbers throughout agricultural sectors. The potential use of biosolid cake as an, effective fertilizer depends heavily on the development of a storage procedure that limits fly breeding and eliminates public concern.

Recent studies have identified several potential management strategies. Preliminary research has indicated that producing a biosolid cake with a moisture content of less than 40% may significantly lower fly breeding success within stockpiles of biosolid cake (Nowergup Report, 2000a). Covers, (either shade cloth or full plastic tarps) placed over the entire surface of the stored biosolid cake, have been identified as an effective barrier to fly oviposition and emergence (Nowergup Report, 2001). Monitoring of stockpiles of biosolid cake located throughout the Central Agricultural Region of Western Australia has identified a potential seasonal effect on fly breeding intensity in stored biosolid cake. Peak fly breeding was noted in stockpiles of biosolid cake throughout November – May followed by a decline to negligible levels during the colder June – October period. Reduced fly breeding may be achieved by timing the transport and stockpiling of biosolid cake with a possible seasonal decline in fly

breeding (Annual Stockpile Monitoring Report, 2002). Additionally, limiting the storage time of biosolid cake prior to use reduces exposure to fly strike and oviposition (Nowergup Report, 2001).

A review of the literature indicates that fly breeding is strongly correlated with temperature and many fly species overwinter as larvae. Seasonal shifts towards cold temperatures can result in reduced fly activity and high mortality rates among many fly populations (Paulin *et al.*, 1998; Berkebile *et al.*, 1994). The seasonal changes in fly breeding levels observed in stockpiles biosolid cake throughout the Central Agricultural Region of Western Australia are regional specific. Timing the transport and storage of biosolid cake with a potential seasonal downturn in fly breeding requires prior monitoring to establish annual fluctuations in fly breeding levels. This report addresses the monitoring results associated with three stockpiles stored at the Nowergup Biosolids Facility (Swan Coastal Plain) between August 2001 and June 2002.

5. FLY SPECIES

The stable fly, *Stomoxys calcitrans,* is abundant throughout the temperate and tropical world and has spread through human activities into the Australasian region. It was first recorded in Australia in 1881 but not in Western Australia until 1912 (Cleland, 1912). *S. calcitrans* is 5 – 7 mm long with a pale spot behind the head, indistinct stripes on the thorax, and seven dark spots on the abdomen. While similar in appearance to the housefly the adult stable fly can be easily distinguished by its biting behavior and the presence of a proboscis (a piercing and sucking mouth part). The proboscis is used to pierce the host's skin to obtain a blood meal (Gerozisis & Hadlington, 1995). Its main hosts are cattle and horses although lesser hosts include man (11% of all bites in USA), dogs, pigs and camels. Bites to domestic stock occur mostly on the lower limbs and belly where animal defense mechanisms such as tail swishing and skin twitching are minimal (Dougherty *et al.*, 1995). The adults feed several times per day, generally in the early morning and late afternoon. Following feeding the fly will move into the shade to digest the meal undisturbed.

Blood meals are obligatory for females before oviposition. A single female can lay between 500 and 600 eggs in her lifetime (22-58 days) creating the potential for rapid population growth. Eggs hatch in 2-5 days and mature to reproductive status in 14-26 days (Gerozisis & Hadlington, 1995). Eggs are commonly deposited in moist and rotting straw (stable litter) especially when mixed with urine or dung (Seddon, 1951). Stable fly larvae have also been recorded in grass clippings (Bull, 1919), rotting vegetation (Roberts, 1952), drifts at the edge of swamps, poultry manure (Dadour, 1994) and associated with horse, kangaroo, wallaby and rabbit droppings (Place, 1915).

Depending on weather conditions, stable flies typically appear in mid-spring, become severe in early summer, and decrease towards the end of summer (Goncalves-Neuza & Veiga, 1994). Monitoring of fly activity during winter indicated that stable flies overwinter as slowly developing larvae in favorable breeding areas (Berkebile *et al.*, 1994). Scant evidence in the literature exists on the stable fly reaching pest proportions (Roberts, 1952).

The cosmopolitan housefly, *Musca domestica,* is associated with man wherever any settlement is made. It was first recorded in Australia in 1849 (Walker, 1849). Adults are similar in size and appearance to stable flies with the exception of the mouth parts. *M. domestica* has sponge-type mouthparts, which are used in the uptake of liquid foods and the

regurgitation of saliva to liquefy solid foods for ingestion. The life cycle of the house fly is around 2 – 4 weeks. An adult female can produce between 200 - 500 eggs during her lifetime (Gerozisis & Hadlington, 1995). It breeds in human, horse, cattle, pig, poultry, sheep and kangaroo dung, rotting vegetable matter, kitchen refuse, lawn clippings and carrion (see Pont, 1973 for review). Eggs hatch in less than two days while larval development and pupation time depends largely on temperature (Gerozisis & Hadlington, 1995). Breeding occurs throughout the year in warmer parts of Australia (Johnston, 1922). Both activity and breeding are strongly influenced by temperature. During colder seasonal conditions houseflies overwinter as larvae although adults can persist indoors giving warmer conditions and breeding has been noted (West, 1951).

There are numerous accounts of the house flys' relationship to public health (West, 1951) and it is best known as a vector of bacteria and protozoa that cause enteric disease (Greenberg, 1971). It is found indoors, and although not attracted to man *per se*, alights on food and food preparation areas. Both sexes settle on and around bacteria harboring breeding sites such as animal waste products and then alternate to food sources that are commonly found in and around human habitation. Bacteria is transferred in the process posing a considerable health risk to humans and rural livestock. (Gerozisis & Hadlington, 1995).

Adult flies of both species are strong fliers, and the recorded flight range of 20 miles (Bishopp and Laake 1921) is probably far short of the house flys' ability. The flight range of the stable fly is at least 135 miles (Hogsette and Ruff 1985). With these capabilities, it is not surprising that both species can locate desirable breeding sites and develop large populations in a relatively short period.

6. CONSULTATION

Water Corporation	V. Metham (Environmental Project Officer) N. Penney (Project Officer – Biosolids Management)

7. STUDY SITE

Approval was sought from the Department of Environmental Protection and the Health Department of Western Australia to conduct monitoring and trials involving the covering of biosolid cake at the Nowergup Biosolids Facility.

The site used in this study was situated along Wesco Road, 36 km NNW of Perth in Nowergup and is leased by the Water Corporation..

8. METHODS AND MATERIALS

Stockpiles

A total of three bunds were established at the Nowergup Biosolids Facility. Each bund was constructed with three walls. Each bund contained approximately 38 wet tones of biosolid cake with an open side for the delivery of biosolid cake. Biosolid cake was sourced from Woodman Point and Beenyup Wastewater Treatment Plants (WWTP) Equal amounts of

biosolids from both WWTPs was used in all three bunds. Biosolid cake produced at the Beenyup WWTP has an 84% water content, while biosolid cake from Woodman Point WWTP has a lower water content of only 72%. The biosolid cake from Beenyup was placed into each bund first followed by the drier biosolid cake from Woodman Point WWTP. The positioning of the drier biosolids acted to hold the wetter biosolids within the surrounds of the bund.

Two of the bunds were then covered with an open weave shadecloth tarp. Covers were positioned over each bund containing the biosolid cake and extended approximately 1m over the sides of the bund walls. Covers were pegged to the ground on all three walled sides of the bunds. At the access side of the bunds, the covers were secured to the ground by concrete filled buckets. This created an almost fly proof environment. The third bund remained uncovered throughout monitoring an acted as a control. Monitoring of three stockpiles of biosolid cake was conducted between the 22/08/01 and the 20/06/02.

Monitoring

Ongoing monitoring of stockpiles of biosolid cake was conducted every seven days over a period of 2 months and then every fortnight for the remaining period. Sampling was reduced to a fortnightly regime based on the significant age of the stockpiles of biosolid cake. Monitoring involved the following:

1. A search for maggot activity within the biosolid cake was conducted and where maggots were observed a sample was taken.
2. In the absence of obvious maggot activity, biosolid cake samples (2 litres each) were collected at random from the more moist areas of each of the stockpiles.

A total of five samples were collected for each biosolid cake stockpile. Each 2 litre sample was placed into a 6 litre container filled with 2 litres of dry sand and then covered with a mesh cloth lid. The presence of sand in the containers facilitated pupation. The samples were watered daily for three days after collection and then left for four weeks to allow for fly emergence. Once adult fly emergence ceased the flies were extracted, identified and counted.

9. RESULTS AND DISCUSSION

Fly Activity

Adult fly emergence results provide a useful indicator as to the presence and absence of fly species at the Nowergup Biosolids Facility. All trapped species are found along the Swan Coastal Plain and all have been associated with manures used in crop production. Four fly species were identified from flies that emerged from biosolid cake samples collected throughout the duration of the trial; *Musca domestica* (House Fly), *Stomoxys calcitrans* (Stable Fly), *Fannia canicularis* (Lesser House Fly) and *Musa stabulans* (False Stable Fly).

Figure 1 presents the total number of each species of fly emerged from samples collected throughout the study period. As expected, *M. domestica* and *S. calcitrans* were the dominant species collected throughout the study duration. Over the duration of the 10 month monitoring period, a low total of only 13 houseflies and 15 stable flies emerged from the collected samples. Of the total flies emerged only 2 flies were collected over the entire 10 month period from the covered bunds (Shade Cloth 1 & 2). Both of these bunds were covered with a shade

cloth tarp limiting fly access to the resource. In contrast, the uncovered stockpile (control) accounted for a huge 94% of total fly emergence highlighting the comparative effectiveness of covers in reducing fly breeding. This is demonstrated in Figure 2 where the total fly emergence numbers of each bund per sampling period is displayed.

The low numbers observed throughout the lengthy 10 months of the trial are indicative of very low fly breeding activity. Extrapolation of adult fly emergence data suggests that ≈ 19,387 flies emerged from the uncovered biosolid cake stockpile over the entire 10 months of the trial while only ≈ 1,175 emerged from a single covered biosolid cake stockpile in the same time. In comparison with previous monitoring of covered and uncovered stockpiles of biosolid cake, the emergence figures obtained are low (see Nowergup Report 2001).

Previous monitoring has indicated that within Western Australia fly breeding in stockpiled biosolid cake declines throughout the June – October period before a gradual increase from late November to May (Nowergup Report, 2001; Annual Monitoring Report, 2002). Adult fly numbers and activity often decline during the Australian winter period due to unfavorable seasonal conditions (Paulin *et al.*, 1998). Colder temperatures have been noted to reduce fly activity and result in high mortality rates among many fly populations. Trials investigating fly breeding in poultry manure have also established that only limited fly breeding occurs during the winter period (Paulin *et al.*, 1998). Monitoring results at the Nowergup Biosolids Facility within the Swan Coastal Plain reflect the same seasonal trends observed in previous studies where fly numbers and fly breeding is negligible during the colder seasons. While low, fly emergence numbers increased throughout the warmer months of November through January in samples taken from the uncovered biosolid cake stockpile (Figure 2). Fly breeding in the shade cloth covered stockpiles remained minimal throughout this period supporting previous findings on the effectiveness of shade cloth covers at reducing fly access and breeding within stockpiles of biosolid cake (Nowergup Report, 2001).

The number of emerged flies recorded in samples taken from the uncovered stockpile throughout the warmer months (November – May) were low. In contrast, fly emergence numbers were considerably more prolific during earlier stockpile monitoring at the same site between the 24.11.00 and the 18.04.01 (Nowergup Report, 2001). The low emergence results obtained throughout the monitoring period appear to support the recent findings of the Annual Stockpile Monitoring Report, 2002. The monitoring results of this report indicted that biosolid cake, stockpiled between June – October and aged by more than three months prior to late November, did not support substantial fly breeding. Biosolid cake at the Nowergup Biosolids Facility was stockpiled in late August 2001 and was just under three months old by late November. In contrast, the biosolid cake of the earlier trial (24.11.00 – 18.04.01) had been freshly stockpiled at the start of the trial in November.

Previous studies have indicated that aged biosolid cake may no longer be an attractive fly breeding resource (Nowergup Report, 2001). The extremely low level of fly breeding observed throughout monitoring suggests that the stockpiles were no longer an attractive fly breeding resource by November 2001. The three stockpiles of biosolid cake were established throughout the colder months when fly breeding levels were naturally low. The expected seasonal increase in fly breeding following November was not observed as the stockpiles of biosolid cake had seemingly become inert to fly breeding.

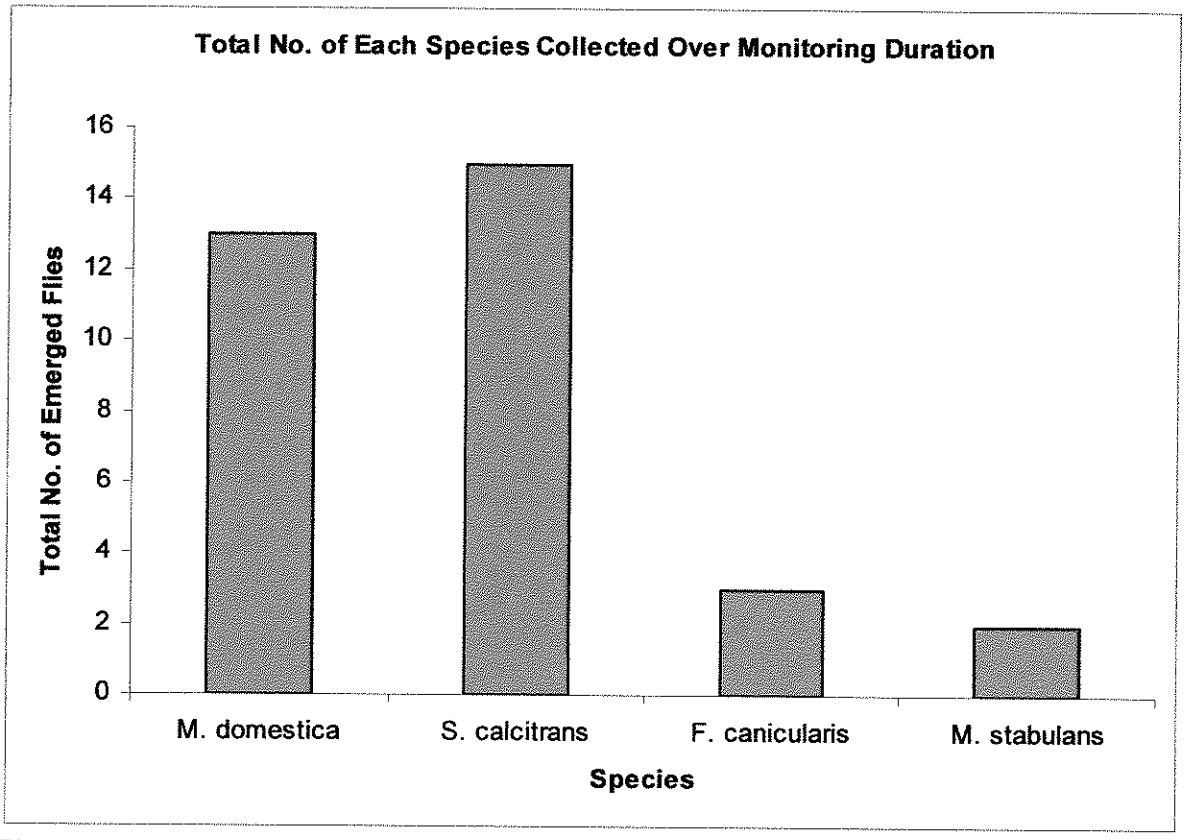

Figure 1: Total number of each species of fly collected throughout monitoring duration from all three stockpiles (bunds).

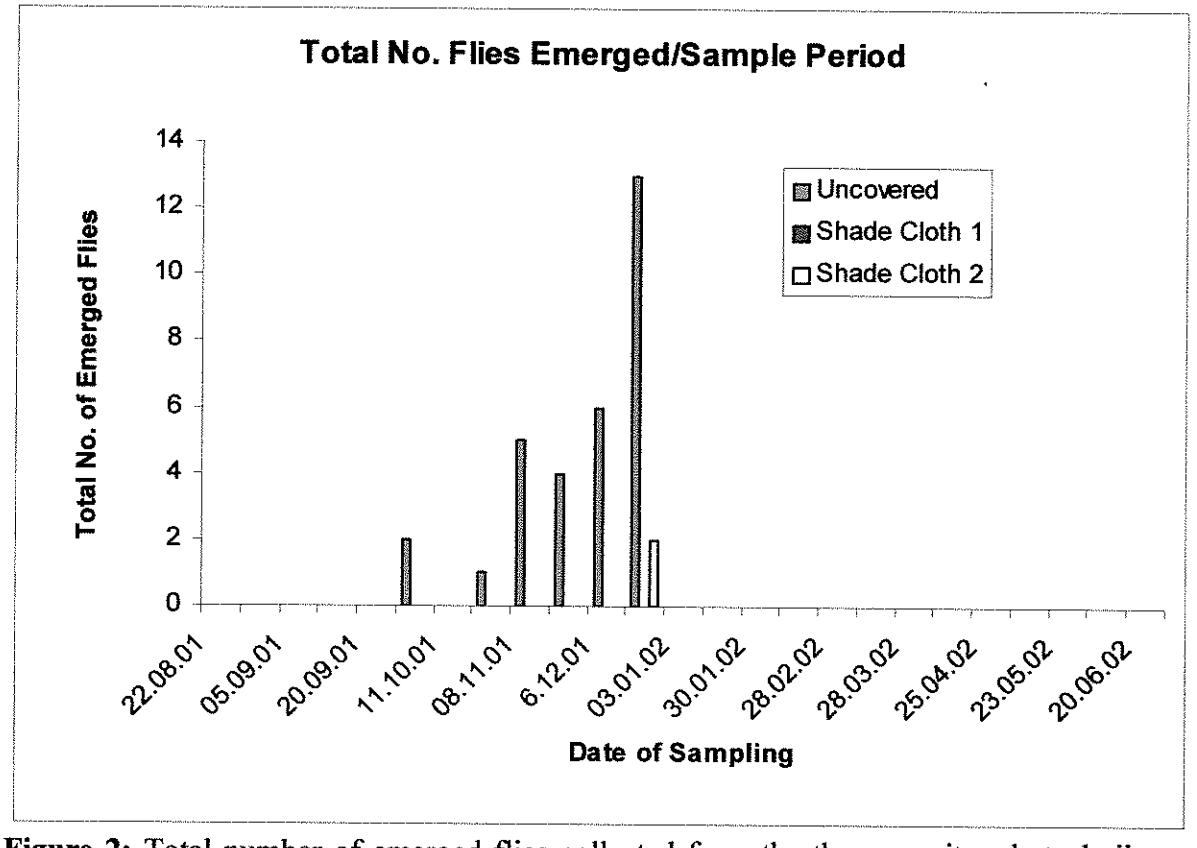

Figure 2: Total number of emerged flies collected from the three monitored stockpiles per sample period.

10. RECOMMENDATIONS

General

Monitoring results indicate that the stockpiling of biosolid cake at the Nowergup Biosolids Facility has resulted in limited fly breeding. Fly breeding in covered stockpiles was extremely low, highlighting the effectiveness of covers restricting fly access to the resource. While fly breeding was negligible in both of the bunds covered by shade cloth, emergence results from samples taken from the stockpiles of uncovered biosolid cake were considerably higher. The presence of shade cloth covers over stockpiles of biosolid cake has previously been identified as an effective means of reducing fly breeding (Nowergup Report, 2001). This is certainly supported on the basis of the emergence results obtained throughout this study. The use of shade cloth covers is highly recommended as part of a fly breeding management program.

Within the uncovered biosolid cake stockpile seasonal fluctuations in fly breeding were observed. Peak fly breeding occurred during the warmer months of November – May and declined during June – October. A similar seasonal trend has been observed throughout the Central Agricultural Region of Western Australia in uncovered stockpiles of biosolid cake (Annual Stockpile Monitoring Report, 2002). However, regardless of seasonal changes and the absence/presence of covers, emergence results were low in all three bunds when compared to previous monitoring results at the same site (see Nowergup Report, 2001). Low emergence results throughout the 10 months of monitoring may be related to stockpile timing. Stockpiles of biosolid cake were established at the end of August during the observed seasonal decline in fly breeding levels. All three stockpiles were just under three months old by November. Previous monitoring results have suggested that stockpiles older than three months are less favorable fly breeding resources (Nowergup Report, 2001). While fly breeding levels were observed to increase throughout the November – May period they were not as high as expected for the locality based on previous monitoring at the site (Nowergup Report, 2001). It is possible that establishing the stockpiles during the period of reduced fly breeding and the consequential age of the biosolid cake is responsible for low emergence results.

Fly breeding in stockpiles aged throughout June – October may be reduced throughout the warmer months of November – May. However, in situations of zero fly breeding tolerance covers are still recommended where possible. The placement of covers over the entire exposed surface of the biosolid cake stockpile is a far more effective method of reducing fly breeding than attempting to match seasonal trends with stockpile age. Unfortunately, given the size of most stockpiles, covers are not always a practical solution. Constraints exist in regard to the implementation of routine covering procedures when dealing with large stockpiles of biosolid cake. In such cases, it is recommended that stockpiles of biosolid cake are established throughout the months associated with a decline in fly breeding (June – October) in Western Australia.

Specific

1. Fly breeding levels were negligible in the covered stockpiles of biosolid cake. Shade cloth covers are highly recommended as part of a fly breeding management program.

2. Where possible biosolid cake should be stockpiled between June – October when fly numbers are lower and fly breeding is minimal.

3. Biosolid cake stockpiled during the peak fly breeding season (November – May) should be spread within a few days to limit fly access and oviposition.

4. There is some evidence that aged biosolid cake is no longer an attractive fly breeding resource (Nowergup Report, 2001). Timing the stockpiling of biosolid cake with the seasonal decline in fly breeding (June – October) may allow an aging period (minimum three months) prior to the fly breeding peak (November – May) resulting in reduced fly breeding.

Future R & D

- Biosolid cake monitoring should be incorporated as part of an overall ongoing 'best practice' fly breeding management program. Continued monitoring of all biosolid cake stockpiling will facilitate the overall management approach regarding the prevention of potential fly problems within the Swan Coastal Plain. Monitoring will ensure fly breeding levels are recorded and assessed at all times providing reassurance for any future public concerns.

- It is recommended that an experiment is designed and implemented with the aim of identifying the effects of seasonal changes and aging on stockpiles of biosolid cake and associated fly breeding.

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