Blanket Pre-Treatment: An Innovative Solution to Some Age-Old Problems

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Abstract. *This paper reports on the successful trials of an innovative method of dealing with significant odour and other environmental issues encountered by a Local Government Authority. Trials first began in 1998 when the City Council was faced with widespread community concern over sewerage odours. Combined with escalating costs for upgrades and on-going maintenance to its sewerage collection and treatment facilities, these presented a real challenge to the Council.*

System-wide incubation and inoculation techniques developed in Queensland and use of EM (Effective Micro-organisms) with assistance from Professor T. Higa and EM Research Organization (EMRO) in Japan were major inputs.

Some important aspects of this unique approach include (a) methods of inoculation resulting in a much lower than expected rate of microbiological augmentation, (b) a system-wide approach rather than focus on trouble spots and (c) an accumulative inoculation pattern.

Introduction Mackay City

Mackay, a city in Queensland of some seventy thousand people, boasts a per capita income in Australia second only to Canberra, the national Capital. The population growth rate in Mackay in the last few years has been one of the highest in the nation. This has put considerable strain on the city's sewerage system and treatment facilities.

Until recently the region's economy has been based on sugar and coal, but development to take advantage of the huge tourism potential is now well established. Combined with a tropical climate and monsoonal weather patterns, this can equate to significant seasonal fluctuations in effluent flow and consequent problems in the handling of effluent.

The city sits across a tidal river 330 km north of the Tropic of Capricorn, and the geology is based on eons of silt and sedimentation. There are areas of natural wetlands that add to problems of drainage and flow and constitute a flood threat. The area also experiences huge tidal rises and falls and these can influence drainage and discharge of effluent.

In addition, Mackay acts as a major gateway to the World Heritage listed Great Barrier Reef Marine Park. In recent years Regional and National Authorities have focussed considerable attention on the effects of sewerage effluent on the Barrier Reef. Corals are particularly sensitive to higher than normal nutrient loads and

consequently, Mackay City Council has been investigating many avenues which aim at higher quality of effluent and reduced risks for the environment.

Due to increased load on the sewerage system in recent years Mackay has experienced a growing problem with sewerage odour. This has resulted in a concerted and very public attempt to find a community-wide solution. The odour problem is centred on effluent arriving at the city's main Sewerage Treatment Facility and at each of the main Pumping Stations across the region.

A series of previous trials were undertaken over a period of three years using chemical and organic additives, physical structures, filters and other processes to try and alleviate the odour problem without success.

Pre-Treatment as a Concept

There has been little change in the practices of waste treatment in Mackay (as in many cities across the world) since the disappearance of night carts that were used to carry away domestic refuse in the late eighteen hundreds. That idea gave way to an installed system of buried pipework. The conventional method of treating sewerage is by transferring effluent through a network of sewerage mains and pumping stations to a sewerage treatment plant at or close to the site where the treated effluent will be released. This is true in Mackay, where effluent is discharged to waters directly behind the Great Barrier Reef after treatment.

As the sewerage passes through the mains and pumping stations, the effluent becomes an incubating culture with the production of a variety of fermentation products including hydrogen sulphide and ammonia. The production and release of hydrogen sulphide particularly, and other undesirable substances in and from effluent can be related to flow rates and detention (Holder and Hanser, 1986). The composition of the sewerage effluent is continuously changing during its passage and is significantly effected by the action of micro-organisms which are present in large numbers in cultures attached to the walls of pipes and other structures over which it passes.

The resulting mixture of material is consequentially accompanied by aggressive atmospheres which continually damage the pipes, pumping and other equipment. In Mackay, as in many other cities, intermittent flow rates, long retention times in the system and a relatively old piping network combine to allow production of large quantities of hydrogen sulphide throughout the entire system.

After various unsuccessful attempts at suppression of odours, it was proposed that an attempt be made using "EM" formulations produced by EM Research Organization (EMRO) and techniques pioneered by Vital Resource Management Pty. Ltd., (VRM) to attack the problem at its source. This involved setting up a series ***of low dose, widespread, accumulative inoculation*** points at which EM formulations are injected. A pattern of inoculation was established such that all effluent in the system if inoculated at least once well before reaching the sewerage treatment plant (VRM, 1999).

The initial intention of this blanket pre-treatment program was to promote the development of a partially self-sustaining culture of competitive micro-organisms

throughout the collection network which would reduce the production and release of hydrogen sulphide (Bellamy, 1998).

As these new cultures became established, it was proposed that inoculation be continued at a level which would promote a change in the overall process of putrefaction of waste and allow a partial breakdown of organic material in the waste without the usual negative by-products (Higa and Chimen, 1998).

The pre-treatment process makes use of the alternation between anaerobic and aerobic conditions which occurs in a piping network to begin some of the processes otherwise reserved for the treatment plant (Bellemy, 1998).

One of the traditional methods of combatting the negative impacts of hydrogen sulphide has been the injection of oxygen to long rising mains. However, the cost of this has become increasingly difficult for Councils to support. An alternative method was thus also sought for addressing the effects of hydrogen sulphide in long rising mains.

Materials and Methods

Initial trials focussed on an area of Mackay's sewerage system known as the Beaconsfied collection system which collects on average approximately 2.4 megalitres of mixed effluent per day. Severe odour problems along this system had resulted in a series of complaints and the formation of a resident's action group. Real Estate values in the immediate vicinity of the main collection station had been dramatically reduced due to the continuous and invasive sewerage odour experienced within approximately one kilometer of the station over many years.

Thirteen inoculation points were selected and equipment installed at each included a specially constructed storage and equipment cabinet and metered dosing equipment capable of continuous inoculation at rates as low as 100 ml per hour.

Extended EM formulation were prepared and diluted at four parts to one with aged (de-chlorinated) water. The resulting mixture was delivered in an even amount to each inoculation site such that a total inoculation of approximately 100 ppm inoculum to waste flow was achieved across the system.

Dosing began on 29 March 1998. After one month, dosing rates were reduced to approximately 25 ppm and thereafter, were progressively reduced to a low of approximately 1.5 ppm. In February 1999, dosing rates were increased to approximately 15 ppm in an attempt to address indicators other than hydrogen sulphide. After a period of one month the inoculation rate was reduced again to 2.5 ppm and continues at that level to date.

In July 1998 the trail was extended to include a second section of the system known as the Slade Point collection system. A further ten inoculation sites were chosen and similar equipment installed. Dosing began on 15 July 1998.

Inoculation sites take two forms: (a) Injection above the influent stream at an existing pumping station; (b) Injection to a specially constructed in-line biological filter (VRM, 1999).

Injection is by way of specially designed nozzles which allow partial aerosoling of liquid and a simultaneous full cone droplet spray. Installation of the spray nozzle is done so as to achieve both a mixture of EM with all effluent in the situation and mist of droplets floating in the ullage space provided above the effluent.

Biological filters contain a quantity of EMX ceramic media which is placed so that effluent passes over and through the ceramic. Inoculation was continued on a 24 hour per day basis and cannister refills were completed on a 10 day rotation.

Sampling points were nominated throughout the area and a routine of data collection was established to allow sampling across a wide range of effluent conditions, flow rates and weather conditions. Community monitors were also selected and interviewed periodically for anecdotal progress information.

Results

The immediate and most notable result of the process was that all detectable sewerage odour normally generated from the system ceased within 24 hours of commencement of inoculation. Anecdotal reports from residents, Council staff and trial monitors confirmed that odours were suppressed both inside structures and in the surrounding areas. This effect was consistent at initial injection to both discrete systems trialed. This was supported by an immediate drop in water-borne hydrogen sulphide readings to a steady reported level of less than one mg/l.

Early in the trial, community monitors reported the appearance of a different odour. This was identified as being odour generated by the EM itself (a sweet fermentation odour). As dosing rates were decreased this odour diminished and is now not detectable.

When inoculation rates dropped below 2.0 ppm, odour was detectable inside the sewerage structures at some points. It was notable that where odours were discovered, new additions to the system had been completed which were collecting effluent not previously inoculated.

Fat build-ups which normally plague most local authority sewerage systems where observed to be significantly reduced. This resulted in much reduced costs for labour in periodic cleaning/removal of fats. It has been noted that fats do not reconstitute downstream of inoculation points and that build-up of fats does not re-occur once cultures of EM are observable in the sewerage system. Any residues are easily hosed from the walls of structures and do not subsequently require mechanical scraping or other removal techniques.

Replacement of Oxygen Injection

A specific trial was conducted to ascertain the effectiveness of using biological processes promoted by EM to replace direct oxygen injection into large rising mains. These trials concluded that where blanket pre-treatment has occurred, the level of DO present in effluent at the end of long rising mains was at least equivalent to that present where direct oxygen injection was undertaken.

Table 1. Comparison of Blanket Pre-Treatment using EM Formulations and Direct Oxygen Injection for Impacts on DO Levels after Long Rising Mains (Source: MCC).

Date	Slade Point System DO mg/l	Beaconsfield System DO mg/l	Andergrove(Control) System DO mg/l
Oxygen Injection and EM at Beaconsifield, Oxygen Injection Only at Slade Point and Andergrove from here			
	Slade Pt	B'Field	Control
11/06/98	0.90	0.00	0.03
15/06/98	5.00	0.83	0.97
Oxygen injection reduced by 50 percent in Slade Pt and B'Field from here			
24/06/98	0.50	1.03	0.45
01/07/98	1.10	0.23	0.07
Oxygen Injection ceased altogether in Slade Pt and B'Field from here			
08/07/98	0.97	1.07	0.87
EM at Slade Point from here			
15/07/98	1.27	0.97	1.37
29/07/98	0.76	0.16	0.50
17/08/98	1.03	1.27	0.00

Following these trials, the Mackay City Council ceased oxygen injection to all areas where blanket pre-treatment is occurring. On-going sampling shows that hydrogen sulphide levels in effluent at the end of long mains is consistently lower with Blanket Pre-Treatment than with oxygen injection.

Containment of a Major Spill

A major sewerage spill occurred on the Slade Point section of the system during the trial period when a contractor ruptured the main transfer line prior to the treatment plant. At the time, even though approximately 6.5 mega litres of raw effluent escaped and lay adjacent to main roads and residential areas for several days, not one complaint of odour was received. Council received positive responses from both community and EPA representatives even though no additional remedial work was undertaken other than to repair the rupture.

The nature of the area provided an excellent opportunity to observe the overall quality of effluent arriving at a point just prior to the treatment plant and the potential positive impacts of increased cultures of beneficial micro-organisms in the pre-treatment phase.

Rupture occurred on 8th April 1999. Works to repair the rupture were completed 14 April 1999. In the interim effluent sat in bright sunshine in shallow sheets covering a large area known as a habitat for bird life. Progress was closely monitored by Council, members of the community and EPA and Health Department delegates. To

date no remedial work has been required and no negative environmental impacts have been recorded.

Table 2. Data from Sewerage Spill on Slade Point Line from Point of Rupture Prior to Sewerage Treatment Plant (Source: MCC and CASCO)

Date	Kjeldahl N mg/*l*	NH_3 Mg/*l*	NO_3 mg/*l*	NO_2 mg/*l*	Total N mg/*l*	PO_4 mg/*l*	S mg/*l*	E.Coli Cnt/100ml
Sample Point 1 (within 50 m of Spill Discharge Point)								
11/04/99	4.2	4.6	0.5	0.01	4.2	2.8	0.02	80000
12/04/99	8.3	9.2	1.8	0.01	8.7	16	0.07	2500000
14/04/99	11.5	12.8	4.8	0.03	12.6	16.5	0.08	1000000
16/04/99	7.6	8.5	9.9	0.01	9.9	9.8	0.4	80000
30/07/99	0.8	0.4	0.9	0.01	1.0	6.6	0.03	1000
Sample Point 2 (100 m from Spill Discharge Point)								
11/04/99	0.9	0.1	0.5	0.02	0.9	8	0.02	150000
12/04/99	11.6	13.1	13.2	0.02	14.6	32	0.64	2000000
14/04/99	11.3	12.8	0.05	0.02	11.3	8.4	0.05	700000
16/04/99	7.6	8.1	9.5	0.01	9.8	8.6	0.24	140000
30/07/99	1.1	0.4	<0.5	0.02	1.1	8.2	0.05	2000
Sample Point 3 (200 m from Spill Discharge Point)								
11/04/99	0.9	0.2	0.5	0.02	0.9	0.6	0.02	50
12/04/99	5.3	5.8	0.5	0.02	5.3	7	0.01	500000
14/04/99	6.4	6.7	0.9	0.01	6.6	4.7	0.01	100000
16/04/99	1.1	0.6	4.2	0.01	2.1	1.5	0.02	400
30/07/99	0.8	0.1	<0.5	0.02	0.8	7.6	0.04	1500
Sample Point 4 (400 m from Spill Discharge Point)								
11/04/99	0.9	0.1	0.5	0.02	0.9	8	0.02	150000
12/04/99	7.6	8.5	4.4	0.02	8.6	11.8	0.24	1500000
14/04/99	7	7.6	0.5	0.02	7	8.5	0.07	500000
16/04/99	5.6	6.0	0.5	0.01	5.6	6.8	0.02	65000
30/07/99	0.8	0.1	<0.5	0.01	0.8	8.8	0.04	1800

Overall Trend Indicators

Over a 12 month period, Council recorded gradual improvement in all leading indicators of effluent quality in samples taken from the end of the collection and transfer lines in the trial area.

At inception of the trial, it was postulated that inoculation over a period of 6 to 12 months would see beneficial micro-organic cultures gradually become resident in the collection network. Hence it was expected that sustained improvements in water quality indicators would begin to appear gradually over a similar period. This effect was borne out by data collected over a twelve month period. In February, 1999 an attempt was made to speed up this process by increasing the rate of inoculation for a period of one month.

Table 3. Collated Effluent Quality Data from Beaconsfield Collection System June 1998 to March 1999

Indicator	1998 16 Jun	24 Jun	1 Jul	8 Jul	15 Jul	29 Jul	17 Aug	1999 3 Feb	10 Feb	30 Mar
TSS mg/l	284	307	366	260	254	269	287	200	139	126
COD mg/l	647	614	879	617	560	600	508	409	362	340
BOD mg/l	224	255	347	266	228	264	213	--	212	150
TKN mg/l	83.1	88.8	91.3	47.2	79.8	81	--	33	34.5	29.9
NH_3 mg/l	--	67.1	38.7	36.8	--	--	51.9	25.2	27.5	23
PO_4 mg/l	9.19	8.92	9.5	6.39	8.88	9.44	7.99	6.15	5.59	1.51

Discussion

It is concluded that by fostering a partially self-sustaining culture of beneficial micro-organisms throughout the sewerage system, it is possible to address at least some of the problems which typically make sewerage collection and transfer difficult and costly.

By combining innovative inoculation techniques developed by VRM with some of the known characteristics of EM formulations, it was possible for Mackay City Council to institute a system wide solution to some long established problems.

Addressing odour problems by promoting beneficial anaerobic activity to compete with and overcome processes which produce odorous substances has allowed the Council to address the cause rather than the symptom of a challenging problem.

At the same time, subsequent effects such as savings in maintenance time and material costs and a saving in the costs of direct oxygen injection emerge as significant benefits for the Council. A significant subsidiary benefit is the reduction of environmental risks associated with accidental spills by having beneficial micro-organic activity already in progress in the collection phase of the system.

As the program continues, it is anticipated that further benefits in terms of reduced augmentation costs at the Sewerage Treatment Plant will arise from the ability to deliver at least partially treated effluent from the collection system itself.

As a result of the considerable success of the program so far, Mackay City Council has committed to the installation of a program covering all effluent in the city and surrounding areas.

References

Bellamy, K. 1998. Method of Treating Waste Water, VRM Enterprises Pty Ltd.

Higa T. and N. Chinen. 1998. EM Treatment of Odor, Waste Water and Environmental Problems

VRM. 1999. Method of Treating Waste Water, VRM Enterprises Pty Ltd, 1999.

MCC. Data Collection and Water Analysis by Mackay City Council Laboratory

MCC and CASCO. Data Collection by Mackay City Council, EPA Queensland and VRM; Analysis by CASCO Laboratories, Mackay Qld.

Holder, G.A. and J. Hauser. 1986. Influence of Flow Velocity on Sulfide Production Within Filled Sewers, 1986.