Impact of Micronutrient Technique (MNT) for biosolids reduction in wastewater treatment plants

Anthony See Yuen To and Alan Kin-tak Lau

Swinburn University of Technology, Victoria, Australia

ABSTRACT

Over the last two decades, the wastewater treatment industry has faced a recurring issue: an overwhelming amount of biosolid (sludge) yield, high power consumption and foul odour due to its anoxic treatment procedures. Engineers in China and Canada have experimented with a different approach, using facultative anaerobic digestion, called the Micronutrient Technique (MNT). This biochemical technique mixes essential growth elements, namely amino acids, vitamins, purine, pyrimidine and minerals, to create MNT mixtures for the WWTP industries. The specific MNT mixture is based on gas detection on-site, the principle of bacterial anoxic reaction. Dosage with MNT has enhanced bioremediation and degradation of pollutants. In the experiment and case studies, it was found that in typical city and some industrial WWTPs, MNT offered a low-cost alternative with encouraging sludge yield and odour control.

KEYWORDS Micronutrient Technique (MNT); aerobic digestion; anaerobic digestion; facultative anaerobic; BOD5; COD; TSS; Fat Oil Grease - FOG; biosolid (sludge) yield

CONTACT Anthony See Yuen To ato@scicorpchina.net

Received 5 September 2020

1. Introduction

Biological wastewater treatment plants (WWTPs) are used by municipalities for the treatment of municipal domestic wastewater and by industries to treat organic wastewater from industrial processes. All biological WWTPs are faced with the problem of treating, separating and disposing of solids (sludge) that are received as part of the influent and that are generated as part of the treatment process.

The types of solids that are received and generated by WWTPs include ash, scum, grease, screenings, grit, and biosolids/sludge (raw, treated, primary, secondary, tertiary, septage, chemical and liquid). A significant portion of the costs to operate any WWTP is related to dewatering, separating, transporting and disposing of solids. As a result, the less solids generated in a treatment plant, the lower its sludge handling and disposal costs will be. Hence, the more efficiently a WWTP is able to reduce the accumulation and formation of biosolids, the lower the operating costs will be for that plant.

As the most numerous classes of organisms on Earth, bacteria have been found in nearly every explored environment and are considered essential and intricately linked to many biological processes. One such impact is the role of bacteria in waste decomposition, specifically in human sewage and biological wastewater treatment. The breakdown of organic wastes is accomplished by a wide variety of bacteria that are naturally present in wastewater and are generally native to the human digestive tract. These bacteria are classified in many ways, including aerobic, anaerobic, and facultative. These classifications describe the bacteria's ability to survive and multiply in the presence or absence of oxygen. This characteristic is important in biological decomposition in waste and wastewater. As such, the design and operation of a WWTP will dictate which groups of bacteria thrive based on a variety of factors including pH, temperature, oxygen availability, macronutrient supply, and the presence of other specific micronutrients (Burgess et al., 1999).

Different groups of bacteria have unique growth requirements, and populations within the same environment generally have independent macro and micronutrient needs. These bacterial populations function in relationship to one another, competing for some of the same growth substrate and organic material. As one group is supplied with the unique resources that it needs, others are outcompeted and do not thrive. This is a dynamic system, with populations changing and shifting based on the changes that occur in the wastewater environment. In this research, conducted across a number of WWTPs, it was discovered that a specific strength found in the same bacterial community due to different food cultures reacted differently in WWTPs (Maat, 2012; Maat, 2014).

Often, the availability of specific micronutrients, vitamins and/or minerals is the limiting factor for growth, especially in wastewater plants where organic macronutrients are plentiful. For this reason, the input of select micronutrients can cause significant, beneficial changes to the nature and efficiency of dominant bacterial populations (Burgess et al., 1999).

This paper and the associated case studies discuss how MNT is able to increase the efficiency at which biological processes are able to reduce biosolids/sludge yield in WWTPs. It provides a high-level summary of the biological decomposition process and identifies the challenges facing wastewater plants in terms of biosolids generation. Additionally, this case study report introduces

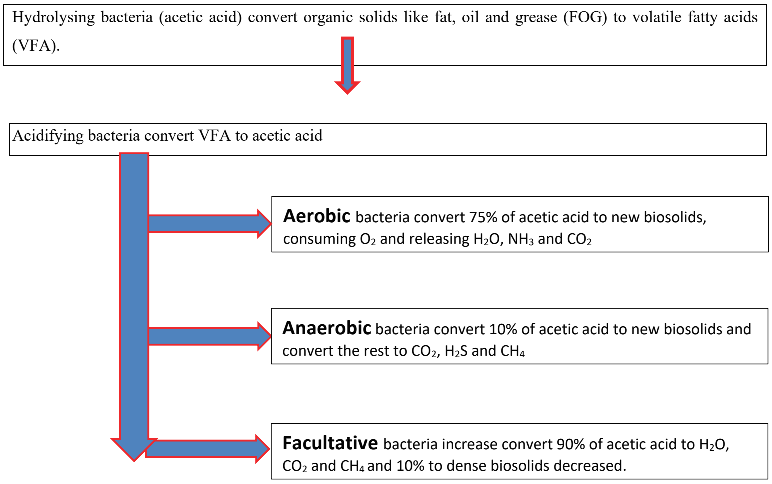

Figure 1. Stages of biological reactions in wastewater treatment plants.

a uniquely eco-friendly alternative to overcoming those challenges using MNT and the specific effect MNT has on the reduction of biosolids in WWTPs.

1.1. Fundamentals of biological decomposition of organic waste

There are many different WWTP types and configurations that utilise a variety of technological combinations to treat wastewater. All plants include one or more of the three main bacterial groups. Below is an overview of the metabolic patterns of these major bacterial groups and the stages of biological breakdown of organic waste in a WWTP.

The biological process begins with bacterial hydrolysis of the organic solids, such as carbohydrates, which are converted to soluble by-products (sugars, fatty acids, amino acids) that become available for other bacteria. Figure 1 explains how organic wastes are biologically converted in different stages in a WWTP.

WWTPs may employ any combination of aerobic, anerobic and facultative processes. The rate-limiting portion of the reaction in removing organic solids is generally the first step identified above, which is the breakdown of solids including fats, oils and grease (FOG) to dissolved carbon-based compounds. The fact that this step is rate limiting causes overall operating issues in dealing with FOG throughout the wastewater treatment process and is a key factor that contributes to incomplete conversion of biosolids in the influent. Often the reason that this step is rate limiting is that the hydrolysing bacteria are not functioning at full capacity due to micronutrient limitations in the sewage.

1.2. Aerobic processes

Many types of WWTP employ activated sludge plants that are designed to maintain populations of aerobic bacteria that feed on dissolved organic matter in the presence of oxygen. Typically, in these processes, 50-75% of the acetic acid generated by the acidifying bacteria is then converted to new aerobic cells (biomass sludge). To process, dewater and dispose of these biosolids is a challenge for all aerobic wastewater plants, and resulting costs associated with this work represents up to 40% of all operating costs. Aerators that provide the necessary oxygen typically meet the demand for O_2 in the aerobic processes. The energy cost to operate these aerators is also significant and can represent up to 30-40% of plant operating costs.

In aerobic systems, the bacteria aggregate in flocs, which are flake-like structures that consist of living and dead microorganisms and the products of their metabolism. Typically, oxygen is unable to penetrate the outer layer of the floc because as the sewage passes through it, the bacteria living in that layer strip all of the oxygen out. This results in aerobic conditions on the exterior of the floc and anoxic conditions on the interior of the floc. The biological processes that take place under aerobic conditions are depicted in Figure 2 (typical reaction is marked in red).

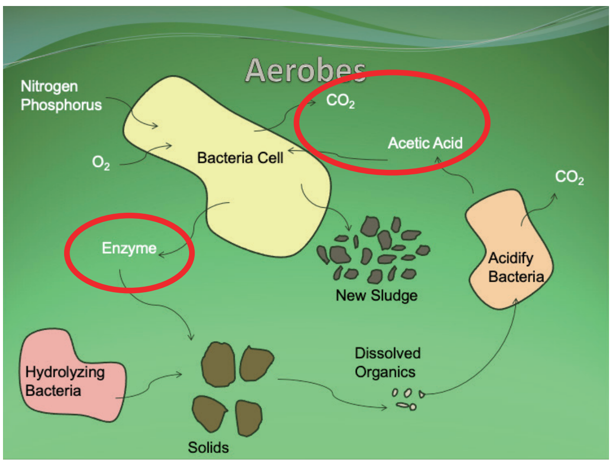

Figure 2. Biological reactions in an aerobic environment.

1.3. Anaerobic/facultative biological processes

Anaerobic processes include a range of biological processes where bacteria degrade dissolved organic material in the absence of oxygen. Facultative bacteria can use either dissolved oxygen or oxygen obtained from sulfate or nitrate ions. Hence, facultative bacteria can live under aerobic, anoxic, or anaerobic conditions. Anaerobic and facultative bacteria generate much less biomass from acetic acid than aerobic bacteria, instead converting it to gases that are released into the atmosphere.

In the final stage of the anaerobic process, methane-producing bacteria and sulfate-reducing bacteria compete for available biomass carbon, producing hydrogen sulfide, methane and carbon dioxide. Depending on the environment within the system, both the sulfate-reducing bacteria and methane-producing bacteria are active.

The generation of hydrogen sulfide (H_2S) and methane (CH_4) by certain anaerobes causes foul odours and has the potential to cause respiratory and neurological illness in operators, and corrosion issues with plant equipment. This is a constant challenge and problem at WWTPs. The biological processes that take place under anaerobic conditions are depicted in Figure 3 (typical reaction marked in red).

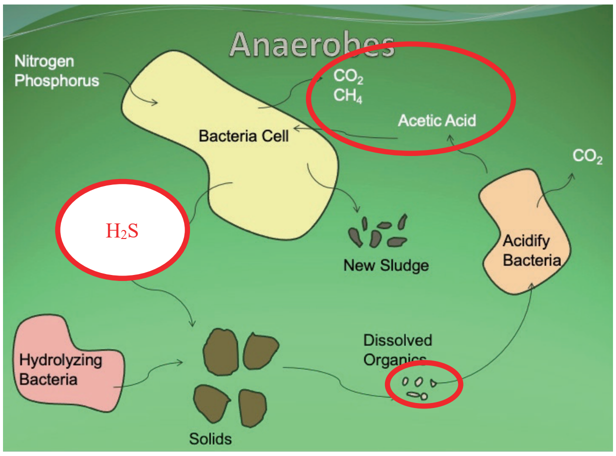

Figure 3. Biological reactions in an anaerobic/facultative environment.

1.4. Optimising the biological breakdown of organic solids

In conventional biological WWTPs, a large proportion of the sludge yield requires final processing and disposal. At most biological WWTPs, it is possible to modify the biological reactions that currently produce fewer biosolids and to further degrade the biosolids produced. Reducing the amount of biosolids that accumulate and are generated in a WWTP is desirable because of the costs incurred in biosolids handling and disposal (Figures 4 and 5).

Sludge processing facilities typically employ mechanical (belt presses, centrifuges etc.) and/or physical/chemical processes (thermal hydrolysis, drying, vacuum filtration) in order to reduce the moisture content of biosolids prior to final disposal. These processes are costly on a per tons basis. Any decrease in the amount of biosolids requiring processing and disposal directly and significantly reduces operating costs.

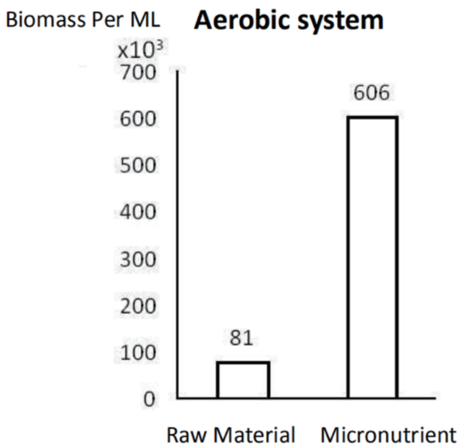

Figure 4. MNT improves aerobic system efficiency.

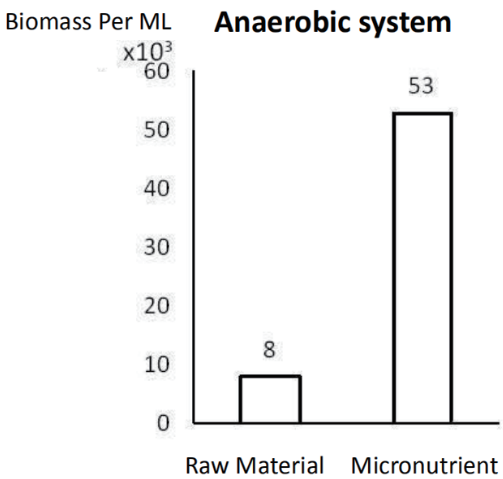

Figure 5. MNT improves anaerobic system efficiency.

2. Material and method

2.1. How Micronutrient Technique (MNT) reduces sludge

MNT involves plant-based compounds see Table 1 organic micronutrients that have been demonstrated to stimulate aerobic, anaerobic and facultative bacteria. The application of MNT is flexible and not dependent on the size of the WWTP or whether it uses a lagoon or septic facilities. The active ingredients in MNT have been shown to significantly enhance microbial activity and metabolic rates in WWTPs while maintaining or improving effluent quality (Hayden, 2013; Guiot, 1992; Luminultra, 2009). This enhanced microbial activity is directly related to

Table 1. Typical MNT ingredients.

Micronutrient Technique (MNT) main ingredients

No	Components	Chemical formula	Percentage of Content (%)		CAS No.	Functions
			Min	Max		
1	Zinc sulphate heptahydrate	$ZnSO_4.7H_2O$	3	4	*7446-20-0*	*Inorganic compound*
2	Manganese Sulphate Monohydrate	$MnSO_4.H_2O$	2	3	*10034-96-5*	*Inorganic compound*
3	Water Soluble Protein		2.3	3.3	/	*Organic Matter*
4	Benzoic Acid	COH_5COOH	0.2	0.5	*65-85-0*	*Preservative*
5	hydroxymethylfurfural	$C_6H_6O_3$	0.2	0.5	*67-47-0*	*Organic Matter*
6	Polysaccharide		4.7	5.7	/	/
7	hydroxy-butanedioic acid	$C_4 H_6 O_5$	0.2	0.5	*6915-15-7*	/
8	Water	H_2O	87.4	82.5	/	/
	total MNT ingredient %		*100*	*100*		

"The MNT is patented technology in PRC (ZL2013. 1. 0281904 .1)"

reductions in the volume of biosolids requiring disposal that has occurred at plants where the MNT mix has been added to the influent. The presence of MNT in the sewage accelerates the biological conversion of the wastewater in the following ways.

These growth factors can be categorised into four main classes: amino acids, pyrimidine, vitamins and minerals (Burgess et al., 1999). In these studies, a population growth rate increase of 500-600 times the previous rate has been observed in typical bacteria like E. coli within 8–24 hours (temperature pending) after dosing with MNT.

The mix of MNT used for this particular study follows (Table 1). The relative concentrations and proportions of these various MNT components have been explicitly engineered to stimulate facultative anaerobes.

2.2. Increased hydrolysis of fats, oil and grease (FOG)

MNT stimulates the bacterial populations that are responsible for hydrolysis of FOG and other biosolids present in wastewater influent by making key micronutrients available to the microorganisms. This results in biosolids being hydrolysed more completely and at a faster rate in treatment plants where MNT is used. The hydrolysis step is the rate-limiting step for the biological removal of solids in many WWTPs.

The evidence that MNT stimulates hydrolysis of solids is seen by the disappearance of accumulation of FOG throughout plants where MNT is used and by significant removal rates of the sludge thickness in holding ponds and lagoons over time.

FOG/slime reduction has consistently been observed from RBC discs, tank walls and other parts of the plant within 30–60 days after first initiating treatment (Oldham, 2013; Villard, 2012; Hoover, 2013). Also, at plants such as Maple Lodge Farms, where prior to treatment upsets would regularly occur due to uneven loading and organic load spikes, the plant became stable with zero upsets following treatment.

Dramatic benefits have also been observed when the product has been applied to anoxic lagoons and holding ponds. When MNT is applied in this situation, the removal rates of COD and TSS accumulated biosolids has been significant and the clarity of the liquid effluent has been greatly improved. A significant result observed after the application of MNT at anoxic lagoons and holding ponds is the release of fine bubbles of carbon dioxide and methane gas at the surface. Biosolids removal rates from municipal lagoons where sludge had accumulated for many years prior to treatment have been observed to be in excess of 80% (Denis, 1991).

2.3. Activating the inner portion of microbial flocs

Typical activated sludge WWTPs stimulate the formation of microbial flocs in aeration tanks. The inner portion of a microbial floc of activated sludge becomes a localised anaerobic environment because the oxygen is stripped from the sewage by the outer aerobic zones of the floc. Typically, the bacteria in these regions do not efficiently contribute to break down the wastewater. MNT stimulates the facultative bacterial populations that are in the inner portions of the flocs so that they much more actively feed on the acetic acid in the sewage. As a result, a higher percentage of the organic load is consumed by the facultative anaerobes and a lower percentage by the aerobes in the plant. This has the effect of significantly reducing the biomass that is generated in the plant, because

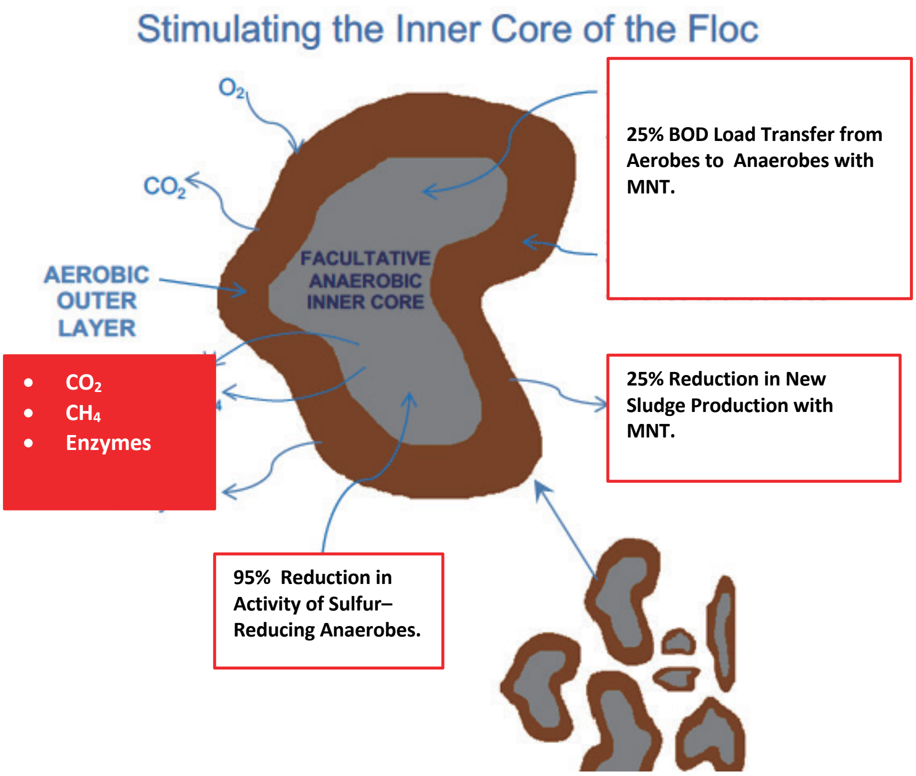

Figure 6. Impact of MNT on biological reactions in flocs.

the facultative bacteria are able to convert a much larger portion of it to carbon dioxide and other gases instead of the aerobic bacteria converting it to biomass. This process is described in Figure 6.

The effects that confirm this process include decreased oxygen uptake rates, increased DO concentrations and increased removal rates of VFA. One case study demonstrated that the addition of MNT resulted in VFA removal rates that were 3–9 times greater than the control where no product was added (Hayden, 2013). The results of this test are presented in Table 2.

Table 2. Impact of micronutrient technique on digester VFA concentrations.

Average VFA Concentration (mg/L)			
	Control	Treatment with MNT	Percent Reduction
Substrate 1	2,404	270	89%
Substrate 2	530	159	70%

Further, in anoxic zones such as holding ponds, the application of MNT will result in significantly enhanced gas bubbling to the surface, without the usual generation of odours. These results have been observed in treatment plants and in scientific studies where MNT has been used (Maat, 2014; Hoover, 2013; Villard, 2012; Hayden, 2013; Guiot, 1992; Oussoren, 2014).

2.4. Inhibition of ammonia and hydrogen sulfide-producing bacteria

MNT has also been demonstrated to significantly reduce the generation of ammonia (NH_3) and hydrogen sulfide (H_2S) gas, as well as other such compounds typically generated in anaerobic portions of WWTPs (Gallop, 2007; Maat, 2014; Villard, 2012; Oussoren, 2014). The prevention of generation and accumulation of these malodourous gases reduces the inhibitory effect of these gases on the biological environment. Studies on the active ingredients in MNT have shown that they create conditions that allow methane-producing bacteria to outcompete hydrogen sulfide producers for the available carbon. In addition, the plant extract ingredients in the product have been shown to block the activity of the enzyme urease, which is a necessary component of the ammonia conversion process. The blockage of the urease enzyme prevents urea present in the waste from being converted to volatile ammonia. This effect has been observed when MNT has been added to hog farm waste, resulting in a 75% decrease in volatile ammonia in animal environments in barns (Paisiovich, 2014). In addition, this process causes the urea to remain in the biosolids, which enhances the fertiliser value of the remaining biosolids.

2.5. Increased biosolids settle ability

MNT has also been shown to improve settle ability in biosolids. This benefit has been observed by monitoring polymer costs for biosolids dewatering, sludge volume index (SVI), suspended solids, supernatant clarity and general observations of the biosolids blanket. These benefits have been observed in many types of WWTP applications where MNT has been used, including facultative lagoons, hog farms, and conventional activated sludge plants (Gallop, 2007; Maat, 2014; Villard, 2012; Oussoren, 2014).

2.6. Daily sludge production at WWTPs

Below are the typical formulas, coefficients and empirical data used to establish the basic design of a complete mix suspended growth biological sewage wastewater process.

To use this formula will require some data for the sewer wastewater, and as a result some basic plant design and effluent BOD data will follow out of this calculation. If the normal sewer water characteristics are unknown, data should be based on historical information or assumption based on experience.

Bacterial growth in the environment for wastewater treatment generally can explained by the following simplified formula:

$$\text{Organics} + \text{Bacteria} + \text{Nutrients} + \text{Oxygen} \rightarrow \text{New Bacteria} + CO_2 + H_2O + \text{Residual Organics} + \text{Inorganics}. \quad (1)$$

Biological growth equation: the biological growth can be described according to the "Monod equation" devised by French Biochemist Jacques Monod (1910-1976):

$$\mu = (\lambda S) / (K_S + {}_S), \quad (2)$$

where μ is the specific growth rate coefficient, λ is the maximum growth rate coefficient that occurs at 0.5 μ max, S is the concentration of limiting nutrient, that is BOD and COD, and K_S is the Monod coefficient.

Several bioenvironmental factors affect the activity of bacteria and the rate of biochemical reactions. The most important factors are temperature, pH, dissolved oxygen, nutrient concentration, and toxic materials. All these factors can be controlled within a biological treatment system and/or a bioreactor in order to ensure that microbial growth is maintained under optimum bioenvironmental conditions. The majority of biological treatment systems operate in the mesophilic temperature range, where the optimal temperature ranges from 20°C to 40°C. Aeration tanks and percolating filters operate at the temperature of the wastewater, which ranges from 12°C to 25°C, although in percolating filters, the air temperature and the ventilation rate may have a significant effect on heat loss. Higher temperatures increase the biological activity and metabolism, which results in increasing of the substrate removal rate. However, the increased metabolism at higher temperatures may lead to problems of oxygen limitation.

2.7. On-site dosing method (WWTP Industrial Code of Practice)

This method is based on site collective measurement of H_2S, NH_3, CH_4, CH_3SH and C_2H_6S etc. in ambient surrounding conditions at the anaerobic processing tank in the WWTP. ppm measurements of these gases are converted to mg/M^3 and applied to the same amount of MNT as the counter measure.

The following is the sample calculation in this code of practice, which was applied on-site:

Molecular weight
H_2S = 34.08 g/mol
MNT mixture = 18.9 g/mol

0.0409 x concentration (ppm) x Molecular Weight = Concentration (mg/m^3), (3)

24.45 x concentration mg/m^3 / Molecular Weight = Concentration (ppm). (4)

Sample Measurement H_2S = 25 ppm
0.0409 x 25 ppm x 34.08g/mol = **34.84 (mg/m^3)**
Dosing MNT : 24.45 x **34.84 (mg/m^3)**/ 18.9 g/mol = **45 ppm MNT**
i.e. 0.0409 x 45 ppm x 18.9 g/mol = **34.78 mg/m^3**

In most cases, the MNT concentration was diluted to 1 part per 500 parts of water to make it easy to deliver; i.e., 20.74 x 0.001g x 500 parts water = 10.37g per m^3. A typical 100 M^3 tank was dosed at 1.037 kg per hours with MNT as per the flow rate increase. If the concentration of H_2S gas increases the MNT dosage also increase by the same percentage.

In most cases, the operator will atomise the diluted MNT and spray it on top of the anoxic tank (see Figure 7).

(a)

(b)

Figure 7. MNT dosing application in WWTP.

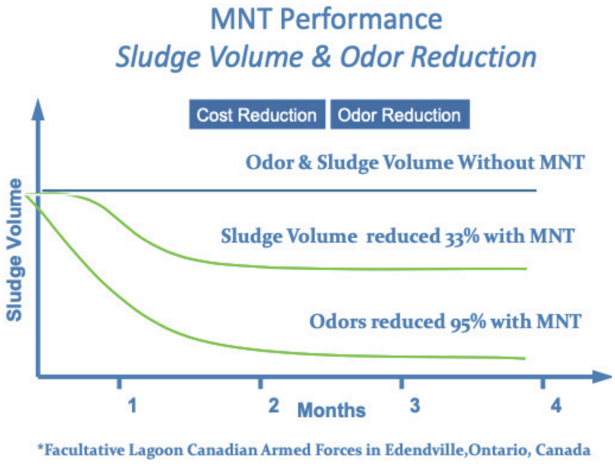

Figure 8. The typical MNT dosing reaction at the Canadian Force Base in Edenvale.

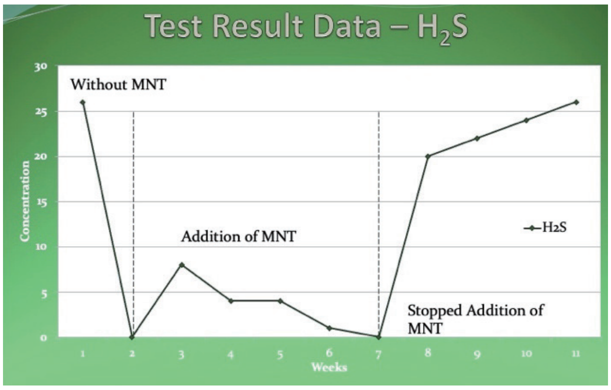

Figure 9. H_2S reduction with MNT dosing.

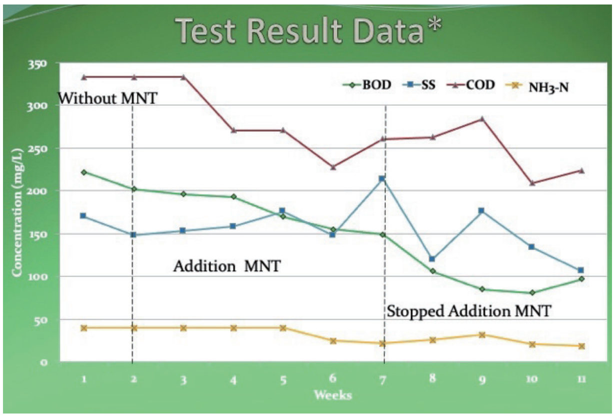

Figure 10. A stable performance when MNT dosing.

3. Result and discussion

The use of MNT has been demonstrated to cause significant reduction in the generation of biosolids in many types of wastewater treatment applications, ranging from laboratory-scale experiments and pilot-scale studies to full-scale activated sludge plants and simple lagoons. The MNT mixture has been shown to be effective at reducing biosolids both in the biomass being generated at a plant and in biosolids that have accumulated in holding ponds and lagoons over a long period of time. The cost benefits of using the product to minimise the amount of biosolids being generated and/or requiring dredging, dewatering and disposal are significant. Below is a summary of select cases where MNT has been applied and the corresponding biosolids reduction benefits that have been achieved.

3.1. MNT results at selected WWTPs

One such example is the Canadian Force Base in Edenvale, at which the overall performance is encouraging (Figure 8, 9 and 10).

The sludge blanket level before and after MNT application was reduced 33% in four weeks, and H_2S reduced from 26 ppm concentrate to 2 ppm or zero measurement. Sooner, the MNT eliminated the sludge blanket and odour.

The performance in North America is summarised in the graph shown below (Figure 11). The TSS and nutrient (pollutants) removal rates are impressive. The odour elimination is outstandingly good.

Table 3. North American case studies.

	Location	Description	Biosolids reduction	Comments
1	Maple Lodge Farms WWTP, Brampton Ontario	2.9 MGD activated sludge plant (Three-month detailed study comparing operating data pre- and post-treatment)	Over 6 months = 26%	Significantly improved effluent quality, improved SVI
2	Stratford Municipal WWWP, Prince Edward Island	0.8 MGD RBC plant with aerated lagoons	Over 4 weeks = 100%	Inventory of accumulated biosolids completely removed; slime on RBC discs removed; much lower turbidity and TSS
3	Canadian National Research Council, Biotechnology Research Institute	Various detailed lab test procedures were carried out on activated sludge under anaerobic and aerobic conditions	In excess of 30% in 6 weeks	Significantly increased rate of secondary clarifier sludge hydrolysis; increase in methane generation by up to 60%, calculated improved plant capacity of up to 30%; reduced oxygen demand by up to 30%
4	Hog Farm, Steinbeck, Manitoba	Long-term hog waste storage lagoon (1.2-million-gallon primary cell) – trial carried out over 6 weeks	4 weeks = 21%	"The set amount from hog manure that is usually like cement after many years of sitting in a lagoon, there were now huge craters, some were 6 feet across and up to 2 feet deep. It was estimated at the time that 1 application of MNT probably recovered up to 250,000 gallons of storage out of a 1.2-million-gallon primary cell."
5	Canadian Forces Base, Edenvale, Canada	Facultative sewage lagoon	4 months = 33% 12 months = 82%	A measurement of the sludge blanket level before and after MNT application resulted in an overall sludge volume reduction of 82%
6	Everton, Ontario	RBC plant	Not measured (zero odour)	Significant removal of FOG and slime on biological contactors

Table 4. People's Republic of China (PRC) Incl. Hong Kong SAR case study.

	Location	Description	Biosolids reduction	Comments
1	Chi Ma Wan WWTP, Lantau Island, Hong Kong.	5 T /day RBC local community treatment plant with large volume sludge issue.	Over 12 months = 100%	Inventory of accumulated biosolids completely removed; slime on RBC discs removed; much lower turbidity and TSS. (Figure 12)
2	Denim Factory 'C' WWTP, Shenzhen, Guangdong, PRC	100 T/day, A_2O activated sludge process. Sludge expansion causing plant overflow and impairing functioning.	4 weeks = 70%	Significant removal of FOG and slime on biological reactor. (Figure 13)
3	Textile Factory 'A' WWTP, Wuxi, Jiangsu, PRC	200 T/day, A_2O activated sludge process. Sludge expansion causing massive H_2S gas accumulation in the plant.	12 months = 96%	Before treatment measured 120ppm, after treatment 15ppm. Sludge sizes reduce significantly.
4	Tannery Factory 'A' WWTP, Jaingmen Guangzhou, PRC	500T/day, A_2O activated sludge process. Sludge expansion causing massive H_2S gas accumulation in the plant.	12 months = 86 %	Before treatment measured 257 ppm, after treatment lower than 36 ppm. Sludge sizes reduce significantly. (Figure 14)

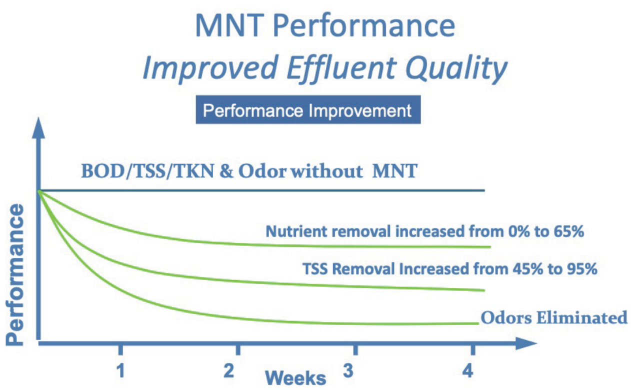

Figure 11. The typical reaction at the above listed sites.

MNT has also performed well in China, due to the food culture and more fatty acids entering WWTPs. The treatment balances the pH levels upon entering the treatment tanks. The following photos show a dryer and more completed digested sludge in WWTP process. Studies show a documented reduction of 95% in foul odour, 60% in sludge handling and 40 in electricity costs in treated WWTPs in China and Hong Kong.

Figure 12. Chi Ma Wan WWTP, Lantau Island, Hong Kong.

(a) Before MNT treatment

(b) After MNT treatment

Figure 13. Denim Factory 'C' WWTP, Shenzhen, Guangdong, PRC.

(a)

(b) Before 257 ppm H_2S

(c) After 36 ppm H_2S

Figure 14. Tannery Factory 'A' WWTP, Jiangmen, Guangdong, PRC.

In the above case studies, there are some clear common benefits among the studied WWTPs. Odour issues were brought under control due to the facultative bioremediation, with less foaming in activated sludge during the reaction. The most encouraging part was the sludge yield reduction, with less moisture deposits and more complete bioremediation. The result is a smaller amount of and dryer sludge in those WWTPs, reducing sludge handling costs and foul odours. A side benefit is less aeration required, which also saves in electricity costs.

4. Conclusions

The following conclusions can be drawn in regards to the impact of MNT on biosolids reduction at WWTPs:

- MNT is effective in stimulating the metabolic rate of aerobic, anaerobic and facultative bacteria in wastewater treatment plants.
- MNT results in increased rates of hydrolysis of FOG and solids, resulting in the removal of the buildup of slime and FOG in all areas of a WWTP.
- MNT is effective at stimulating hydrolysis of accumulated biosolids in lagoons/holding ponds, resulting in significant reduction of biosolids volumes.
- The use of MNT stimulates the metabolic rate of both aerobes and anaerobes, resulting in the transfer of approximately 25% of the incoming BOD load from aerobes to the anaerobic/facultative bacteria in the aerobic reactors. This results in an increase of the organic load treatment capacity of the entire WWTP.
- The generation of noxious and malodorous gases, including hydrogen sulfide and ammonia, are inhibited.
- Settle ability and density properties of biosolids are improved, as are suspended solids removal rates.
- WWTPs that employ the use of the product can reasonably expect sludge/biosolids reduction rates of 25% or greater.

MNT ingredients are plant-based, non-toxic and not harmful to the environment. This is a low-cost alternative to conventional polymer-type flocculants like PAM and PAC.

MNT has the disadvantage of a slower reaction time, roughly 48–72 hours compared with 4–8 hours with chemical and polymer treatment. However, combining MNT with constructed wetland (CWs) or other wastewater treatment techniques like vermifiltration (VF) and natural media filtration (NMF) can bridge this shortcoming (To et al, 2021).

Notes on contributors

Ir Dr Anthony See Yuen To is a professional engineer from Hong Kong. He first received his education in the United Kingdom and later his Ph.D. at Swinburn University of Technology, Australia. Over his 38-year career in engineering and senior management at multinational companies, he shared his expertise in environmental engineering, manufacturing and construction management in UK, USA, PRC, Macao and Hong Kong.

Ir Dr To is the founder and currently the CEO of Scicorp (China) Co Ltd., an environmental engineering company with offices in the People's Republic of China, Hong Kong and Macao.

Prof Alan Kin-tak Lau is a practical engineer, an academic and a manager in both the academic and commercial sectors. Prof Lau is Pro Vice-Chancellor (Research Partnerships and Digital Innovation) with Swinburne University of Technology. He is an Independent Non-Executive Director of King's Flair International (Holdings) Limited. Prof Lau was the first foreign Vice-President of the Institution of Mechanical Engineers from 2014 to 2019. He is adjunct professor for five universities in the world and named as Australian Research Theme Leader in Composite Materials.

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