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Concept for Separation of Different Wastewater Streams in order to Minimize Emerging Contaminants in Drinking Water

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Abstract: In the recent past trace levels of many contaminants were reported in drinking water. Substances that are resistant to bacterial degradation will flow along with treated effluent and will end up in inland surface waters from which raw water is extracted for public water supply systems. In certain extreme situations, presence of excessive concentrations of these contaminants can inhibit bacterial degradation of biological wastewater treatment processes. Therefore there is a natural tendency for build-up of these contaminants in water sources. The emerging contaminants found in drinking water are heavy metals and hazardous substances that flow along with industrial effluent, hospital effluent and agricultural runoff.

In order to remove these substances that are resistant to biological wastewater treatment, it is recommended to separate them in concentrated form by a separate collection system without allowing to mix with other wastewater streams.

For wastewater other than domestic nature containing heavy metals, residual dyes etc. and hazardous wastewater generated from hospitals such as radioactive iodine treatment for cancer patients, chemicals used for X Ray processing, Amalgam used by Dentists to fill up cavities, Antibiotics, Laboratory chemicals such as Salicylic Acid, Benzoic Acid, Ethidium Bromide (used for molecular biology research), Xylene, Formalin for preserving biological specimens, etc. must be separated in concentrated form in a separate collection system without mixing with wastewater of domestic nature and disposed after treatment as hazardous wastewater. As per the "Policy on siting of high polluting Industries" it is not possible to locate industries that are categorized as Type "A" high polluting industries upstream of intakes that extract raw water to produce potable water supply as it is very difficult to remove these substances by conventional water treatment techniques.

Key words: Emerging contaminants, hazardous wastewater, wastewater separation

1. Introduction

In the recent past trace levels of many contaminants were reported in drinking water. Substances that are resistant to bacterial degradation will flow along with treated effluent and will end up in inland surface waters which extract raw water for public water supply. In some extreme situations, presence of excessive concentration of these contaminants can inhibit bacterial degradation of biological wastewater treatment processes. Therefore there is a natural tendency for build-up of these contaminants in water sources as treated effluent is discharged in to inland surface waters.

Substances such as methyl mercury can lead to bio magnification in the food chain. In Minamata Bay in Kiyushu Island in Japan people experienced the Minamata disease as a result of discharge of organic mercury which lead eating of contaminated sea food. DDT is also banned in most countries because it has the ability of bio magnification along the food web.

The emerging contaminants found in drinking water in Sri Lanka are heavy metals and hazardous substances that flow along with industrial effluent, hospital effluent as point sources while agricultural runoff as non-point sources.

As per the "Policy on siting of high polluting Industries" the Joint Cabinet Paper on No 3(i)/1/23(Xiii) dated 29th April 2009 by the Ministry of Water Supply & Drainage and Ministry of Environment which will not allow to locate industries that are categorized as Type "A" high polluting industries upstream of intakes that extract raw water to produce potable water supply as it is very difficult remove these substances by biological wastewater treatment processes.

In order to carryout appropriate treatment/disposal for wastewater having different characteristics, NWSDB's "Concept for wastewater separation in major institutions" was developed and adopted in year 2009.

2. Hypothesis

2.1 Waste minimization

Wastewater characteristics differ dramatically from industry to industry hence industry specific wastewater treatment plants are different from industry to industry. Significant amount of wastewater generated from many industries of domestic nature without heavy metals and toxic substances. However when wastewater of domestic nature mixed with heavy polluting streams of the industry it is very difficult to remove these substances. In higher concentrations, heavy metals and toxic substances present in wastewater may hinder the biological treatment processes. Therefore it is of paramount importance that these heavy polluting streams from the industry must be separated in concentrated form and treated by appropriate technique in order to recover, reuse these substances back in the industry or dispose as necessary without allowing to mix with low polluting wastewater streams. During retrofitting or building new industries, the industrialist should incorporate machinery and equipment that will minimize heavy polluting streams. Selection of proper raw material having low residual contaminants can also minimize pollutants in the effluent. By applying cleaner production techniques such as cascade washing or counter current washing in plating industry will minimize fresh water usage.

Once heavy polluting streams are separated in concentrated form and carryout appropriate pre-treatment is done, major portion of the wastewater generation from industries can be treated using biological wastewater treatment techniques.

2.2 Equalization/Neutralization

In order to ensure uniform wastewater characteristics entering industrial wastewater treatment plants, it is necessary to have an equalization/neutralization tank with mixer/bubble aeration to prevent settlement and to control odour. In case of some industrial wastewater of acidic or alkaline in nature require NaOH or HCl dosing to address pH correction at Equalization/Neutralisation tank.

2.3 Grease and Oil Interceptors

In order to prevent accumulation of grease/oil/fat in the sewer network and to reduce sewer cleaning frequency it is necessary to have a grease interceptors especially for Restaurants, Hotels, and Takeaway shops. However for sizing of the grease interceptors it is possible to separate wastewater from food processing area, to satisfy the requirement of grease trap needed only for that particular area and the remaining wastewater can be mixed with the effluent of the grease trap/oil interceptor.

In case of industrial wastewater having grease and oil, it may be necessary incorporate API (American Petroleum Institute), CPI (Corrugated Plate Interceptors) or DAF (Dissolved Air Flootation) or any other suitable method depending on size of oil droplet diameter [1].

Transformer coolant oils such as PCB (Polychlorinated Biphenyl) are carcinogenic hence should not be discharged in to water bodies under any circumstance.

2.4 Separation of Toxic/Inhibiting substances

It is very much important to separate toxic/radioactive/inhibiting substances being mixed with wastewater of domestic nature in order to carryout appropriate specific treatment. In hospitals the waste streams from radioactive iodine therapy, pharmaceutical wastes/antibiotics, residuals of Amalga and effluent from X Ray process consisting with heavy metals, Laboratory wastewater such as Xylene, Formalin, Ethidium Bromide, Salicylic etc. should be separated at the source as concentrated form as possible with separate collection system so that the wastewater having domestic nature can be treated by biological treatment methods without any difficulty. The heavy polluting wastewater streams have to be treated separately as hazardous wastewater and disposed appropriately.

- Tariff Structure

For the wastewater emanating from the National Institute of Cancer, Maharagama, NWSDB obtained concurrence from Atomic Energy Authority (AEA) about requirements for retention time in the delay tanks in order to achieve radiation levels for alpha and beta to meet inland surface discharge standards. A battery of 6months delay tanks were constructed incorporating 3mm stainless steel jacket inside of 250mm thick concrete walls. Once capacity of these tanks reach full level, officer from AEA will close the inlet and leave for 6month, after which radiation level will be checked and effluent is directed to the sewage pumping station which intern discharge to Biological Nutrient Removal Wastewater Treatment Plant at Moratuwa/Ratmalana and final effluent is discharged vial 550m long sea outfall which is equipped with diffusers to enhance instantaneous dilution of treated effluent which has already treated up to meets inland surface discharge standards at the treatment plant.

Large quantities of antibiotics are administered to humans and animals to treat diseases and infections every year. Antibiotics are also commonly used at subtherapeutic level to livestock to prevent diseases and promote growth. Antibiotics are among the emerging micro contaminants in water because of concerns of their potential adverse effects on the ecosystem and possibly on human health. Antibiotics are likely to be released into the aquatic environment via wastewater effluent and agricultural runoff as a result of incomplete metabolism, ineffective treatment removal or improper disposal. Ching et al [2].

2.5 Wastewater treatment process selection criterion

The wastewater treatment process has to be chosen with due consideration for following aspects but not limited to;

- Influent wastewater characteristics
- Requirements of the disposal standards or ultimate end use (discharged to inland surface water body, sea outfall, irrigation, effluent re use for non-portable uses, ground water recharge etc.)
- Availability of land
- Energy consumption/recovery
- Capital cost
- Operation and maintenance cost
- Availability of skilled personal

3. Verification

Antibiotics were categorized according to their chemical and structural properties. members of the same class of antibiotics have similar structure, act by similar mechanisms, and are likely to behave similar in the environment. More than ten antibiotic classes (aminoglycoside, ionosphere, β -lactam, macrolide, polypeptide, quinolones, sulphonamide, tetracycline, streptogramin and other) are currently in use. Among the antibiotic classes six are important in both human medicine and animal husbandry (amminoglycoside, , β -lactam, macrolide, quinolones, sulfonamide, tetracycline). Forcus of on these six antibiotic classes because of the high risks for human health if they present in water as contaminants. The cross use of these antibiotics classes both in human and animals may lead to a more rapid development of bacteria resistance towards these drugs. Ching et al [2]

According to Ching et al [2], among the β -lactam, macrolide, sulfonamide and fluoroquinolone classes, the estimated concentrations for these antibiotics in USA in untreated municipal wastewater are listed in Table 1.

Table 1: Predicted concentration of antibiotics in untreated municipal wastewater.

Antibiotic	Class	Predicted wastewater con. (ng/L)- excluding metabolism		Predicted wastewater con. (ng/L)- including metabolism	
		Predicted wastewater con. (ng/L)- excluding metabolism		Predicted wastewater con. (ng/L)- including metabolism	
amoxicillin	β -lactam	27,000		16,000	
azithromyc	macrolide	9,200		NA	
in					
sulfametho	sulfonami	3,800		3,200	
xazole	de				
ciprofloxac	fluoroquin	3,100		1,400	
in	olone				

NA = not available

Table 2-13 to Table 2-15 of Metcalf & Eddy [4] specifies "Metal concentrations threshold of inhibitory effect on heterotrophic organisms", "Typical waste compounds produced by commercial, industrial and agricultural activities that have been classified as priority pollutants" and "Typical discharge limits for toxic constituents found in secondary effluent" respectively.

According to Wikipedia [3] dental amalgam is a liquid mercury and metal alloy mixture used to fill cavities caused by tooth decay. Low-copper amalgam commonly consists of mercury (50%), silver (~22-32%), tin (~14%), copper (~8%) and other trace metals. According to Water World Magazine [7], USEPA study shows that half the mercury enters water treatment facilities from Amalgam which is mixture of mercury and other metals. USEPA propose common sense of rules to cut down the metal discharges to water treatment facilities by 8.8 tons per year and is open for public comments and expects to finalize the standards by September 2015.

According to Water World Magazine [7], a new survey conducted by NSF International find 82% of the consumers are concerned about emerging contaminates in drinking water. Emerging contaminates refers to prescription drugs, over the counter medication, detergents, pesticides, herbicides. Although health risks associated with trace levels of these contaminates are not yet well understood, their presence in drinking water have many consumers concerns. Despite their concerns. Interesting to note though study shows only 28% correctly bring medication to pharmacists or clinic for proper disposal while others say throwing them to trash or flushing them down the toilet.

According to Wijesinghe et. al. [8] indicates that mean concentration of Cadmium and Led in Kelani river for year 2001 to 2004 have exceeded limit specified by SLS 722, "Raw water extracted for drinking purpose" as shown below,

Table 2: Heavy metal concentration in Kelani River 2001 to 2004

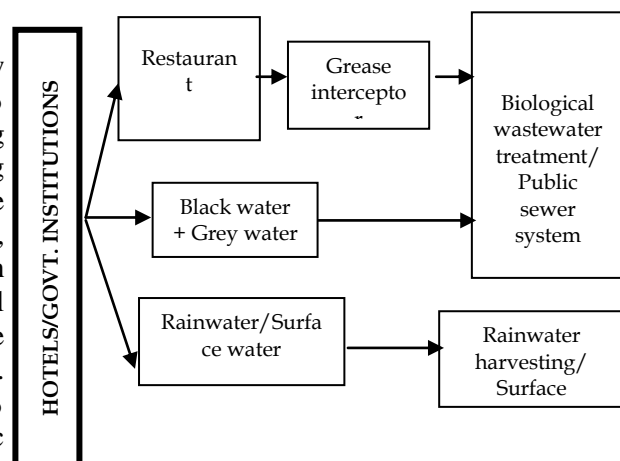
Year	Pb		Cd	
	Mean Concentration in Kelani River	As per SLS 722 (mg/l)	Mean Concentration in Kelani	As per SLS 722 (mg/l)

	(mg/l)		River (mg/l)	
2001	0.086	0.05	0.005	0.005
2002	0.027	0.05	0.008	0.005
2003	0.155	0.05	0.004	0.005
2004	0.080	0.05	0.009	0.005

4. Conclusions

As per the NWSDB's Concept for Wastewater Separation in Major Institutions [5], wastewater having different characteristics should separated in concentrated form in separate plumbing system as follows and carryout appropriate treatment/disposal in order to control emerging contaminants in drinking water;

4.1 Wastewater from hotels and Government Institutions that producer's wastewater of domestic nature can follow concepts similar to the following;



4.2 Wastewater from hospitals could carry out following in line with the concept for wastewater separation;

- **wastewater of domestic nature, rainwater/storm water and food processing** should be carried out in line with 4.1
- **Wastewater resulting from radiation therapy treatment** should be kept for 6 months in delay tanks having 250mm thick concrete walls comprised with 3mm thick stainless steel jacket, 250mm thick concrete slab as per AEA recommendations

- **Wastewater from X Ray Processing** can be collected in containers in concentrated form in separate collection system (silver can be precipitated and separated from water phase)
- **Dental Wastewater resulting due to Amalgam** used to fill cavities. Amalgam consist of 50% Hg, 22-32% Ag, 32% Sn, 8% Cu (Ref. Wikipedia). This should be collected in containers in concentrated form in separate collecting system. This should be treat/dispose as hazardous wastewater.
- **Antibiotics/pharmaceutical wastewater** should be collected in containers in concentrated form in separate collection system. Suitable deactivation of antibiotic should be carried out (thermal, alkali/acidic, chemicals such as peroxides)

Human exposure to pharmaceuticals through drinking water can be reduced through a combination of preventive measures, such as take-back programmes, regulations, public guidance and consumer education to encourage the proper disposal of unwanted pharmaceuticals and minimize the introduction of pharmaceuticals to the environment [9].

With respect to conventional drinking water treatment, bench scale studies showed that coagulation (with or without chemical softening) is largely ineffective in removing pharmaceuticals [9].

- **Ethidium Bromide, Salicilic, Xylene, Formalin and other laboratory wastewater** should be separated in concentrated form in separate plumbing system, treat and dispose as hazardous wastewater (scheduled waste)

4.3 Industrial wastewater consisting with heavy metals

- Heavy polluting industries categorized as type "A" [6] should not be established upstream or downstream (up to stretch that can back flow of pollutants to the intake along with salinity wedge during high tide period where intakes are closer to the sea)

of major rivers that extract raw water to produce potable water.

- Implement interceptor sewer to bring the treated effluent from Biyagama Export Processing Zone (BEPZ) and the effluent from other heavy polluting industries located upstream of Ambatale and Kelany Right Bank (KRB) intake downstream of proposed salinity barrier.
- For wastewater having Cr^{6+} to be first converted to Cr^{3+} by mixing with waste Fe^{2+} while controlling the oxygen reduction potential between 250 and 350mv at desired pH
- Dewatered sludge should be disposed in compliance with the requirements stipulated in EU Council Directive 86/278/EEC for land application of Sludge until a local standard is established
- pH requirement for different metals [1] should be controlled in the desired range depending on level of removal desired for different metals based on Fig. 1, followed by coagulation, flocculation and sedimentation

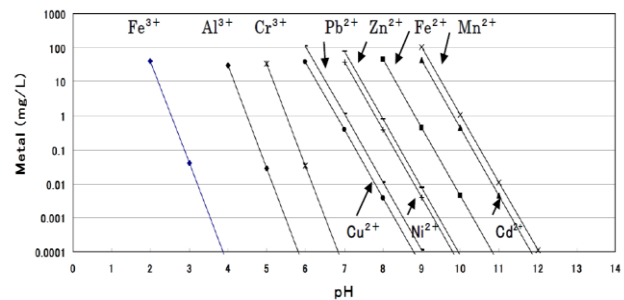


Fig.1 Relationship between solubility of metal ion and pH

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