Microbial and Heavy Metal Contamination of Treated Hospital Wastewater in Thailand

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Objectives : *To determine the microbial and heavy metal contamination of treated hospital wastewater.*
Material and Method : *Methods of treating wastewater were acquired by questionnaires. Chlorine concentration, pH, bacteria and parasites in treated wastewater were tested in the individual hospitals. Heavy metal concentrations were measured by atomic absorption spectrophotometry.*
Results : *In 2002, 72 hospitals were included in the present study. The common methods of treating wastewater were activated sludge and oxidation ditch. Bacteria exceeded standard numbers, pathogenic bacteria and parasites were found in two-thirds of the hospitals. Heavy metals, namely lead, chromium and cadmium, in the hospital effluent did not exceed standard concentrations.*
Conclusion : *Micro-organisms exceeding standard levels were found in treated wastewater in two-thirds of the hospitals. Lead, chromium and cadmium levels in hospital effluent were in an acceptable range.*

Keywords : *Contamination, Microbial, Heavy metal, Wastewater, Hospital*

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Wastewater released from hospitals could be loaded with pathogenic micro-organism and toxic chemicals. Improperly treated hospital wastewater is not safe for reuse or for releasing into natural water sources[1,2]. In every hospital in Thailand, wastewater is treated before being released by different methods. Standard levels of micro-organisms and heavy metals in released hospital wastewater have yet to be observed in Thailand[3]. To assess the risks from hospital wastewater, a study on microbial and heavy metal contamination of wastewater released from hospitals was done.

Material and Method

Hospitals were enrolled by stratified sampling according to size and location. Methods of treating hospital wastewater, pH levels of wastewater after treatment, disinfectants used were acquired by a set of questionnaires. Samples were collected twice monthly for 5 months from each hospital. For laboratory studies, approximately 100 ml. of treated wastewater were collected by a sterile glass container. To neutralizing chlorine, 0.1 ml of 1.8% of sodium thiosulfate was added immediately after collection. Culture for bacteria was done within 3 hours after collection. Standard plate count and coliform count and isolation of pathogenic bacteria were done by standard methods. Microscopic examination was done within 3 hours after sample collection by filtering 100 ml of samples. The membrane was then washed with 5 ml. of sterile water. The mixture was centrifuged at 2000 r.p.m. for 1 minute. The sediment was examined for parasites under a microscope. For determination of heavy metal, 100 ml. of the treated wastewater was collected and acidified with 1.5 ml. of 65% nitric acid. The samples were transported to Siriraj Hospital and analyzed for lead, cadmium and chromium by atomic absorption spectrophotometry. Reference quality standards of waters were used.[4-11] Categorical variables were presented in frequency and percentage respectively. Mean $\pm$ SD and range were expressed for continuous variables.

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Results

The study was done during July 2002 and September 2003. Seventy-two hospitals were randomly enrolled. The types of hospitals are shown in Table 1. The number of hospitals located in the central, northeastern, southern, northern and eastern regions were 33, 13, 12, 8 and 6 respectively. There were five methods of treatment of wastewater. The method mostly used was activated sludge (47.2%) followed by oxidation ditch (38.9%). The mean pH of treated wastewater was 7.07±0.74, and 98% of the samples were within standard levels (pH 5 to 9). Chlorine was used as an infectant in 93% and the mean chlorine concentration of the sample was 0.69±0.55 ppm, and the range was 0-33 ppm.

Microbial contamination of treated wastewater is illustrated in Table 2. Exceeded standard levels of total coliforms and fecal coliforms were found in 5.6% and 20.8% of samples in 8.3% and 41.7% of hospitals respectively. Pathogenic bacteria : *Vibrio* and *Salmonella* spp. were found in 3.1% of samples and in 12.5% of hospitals. Other potentially pathogenic bacteria were found in 20% of samples and 43.1% of hospitals (Table 3). Human parasites were found in 20.3% of samples from 41.7% of hospitals. *Strongyloides stercolaris* was the most prevalent followed in rank by hookworm and *Opisthorchis viverini*.

Table 4 illustrates the number of hospitals in which treated wastewater contained fecal coliforms exceeded standard levels, pathogenic bacteria and parasites. Fecal coliforms of over 1000/100 ml of treated wastewater was found in 41.7% of hospitals. Pathogenic bacteria and parasites were recovered in wastewater in 11.1% and 41.7% of hospitals respectively. Treated wastewater met microbiological standards in 24 hospitals (33.3%).

Lead, chromium and cadmium were chosen as representative heavy metals to be tested. The levels of these heavy metals in treated hospital wastewater were within permissible levels (Table 5).

Table 1. Characteristics of participating hospitals

Hospitals	Total	Methods of hospital wastewater treatment *				
		AS	OD	SP	AL	RBC
University	5	3	-	1	1	-
Regional	15	9	6	-	-	-
Provincial	25	6	19	-	-	-
Community	13	6	1	6	-	-
Bangkok Metropolis	4	2	2	-	-	-
The Armed Forces	3	1	-	1	-	1
Private	7	7	-	-	-	-
Total	72	34	28	8	1	1

*AS, activated sludge; OD, oxidation ditch; SP, stabilization ponds; AL, aerated lagoon; RBC, rotating biological concentration

Table 2. Total coliform and fecal coliform bacterial counts in treated hospital wastewater (%)

	Bacterial counts (MPN/100 ml) *****	**(%)** **Samples** (n=360)	**Hospitals** (n=72)
Total coliforms	0	33.0	58.3
	2 - 5,000	61.4	84.7
	> 5,000**	5.6	8.3
Fecal coliforms	0	51.1	77.8
	2 - 1,000	28.1	61.1
	> 1,000**	20.8	41.7

***** MPN, Most Probable Number/100 ml.

**the maximal levels of the standard quality of clean surface water class II[5-7]

Discussion

The study was aimed to explore the danger of wastes generated in hospitals to the public. Wastewater treatment requires appropriate methods and constant monitoring to ensure that the treated effluent be not hazardous to the environment. This research covered a large number of hospitals so that the results could represent hospitals of all sizes and in all regions of the country.

The methods for treating hospital wastewater were mainly activated sludge and oxidation ditch (Table 1). These treatment plants required less space and produced less bad smell compared to other methods. However, the two mentioned methods are less effective in eliminating bacteria and parasites[11-15].

According to the revised guidelines on the quality of treated wastewater used in agriculture, in public parks, fecal coliforms not exceeding 1000/100 ml. and 0.1 parasite egg/1000 ml. are required[5,6]. Two-thirds of the hospitals studied failed to fulfil the requirements. Total coliforms of over 5,000/100 ml were found in 5.6% of samples in 8.3% of hospitals and fecal coliforms exceeding 1,000/100 ml in 20.8% of sampled water from 41.7 of hospitals (Table 2).

Pathogenic bacteria, for example, Vibrio species. Salmonella species were found in the treated wastewater as well as other potentially pathogenic bacteria (Table 3)[16-17]. Human parasites in treated effluent were found in 20.3% of samples and of 41.7% of hospitals. The high contamination of bacteria and parasites in treated wastewater reflected the faulty processes[18-22]. The whole process of treating wastewater should be periodically reviewed. One important mistake identified in the present study was the inadequate concentration of chlorine in the final disinfection of treated water before being released into natural sources. Contamination of treated wastewater with potentially pathogenic micro-organisms was found in all categories of hospitals (Table 4). Fecal coliforms of over 1000/100 ml, pathogenic bacteria, human parasites were found in 41.7%, 11.1% and 41.7% of hospitals respectively. In 6 hospitals, the total coliforms over permissible levels, pathogenic bacteria and parasites were found in treated wastewater. The treated hospital effluent could contaminate the natural water sources and environment leading to human infections[16,17].

The finding that concentrations of lead, cadium and chromium in hospital effluent were within standards was encouraging. Studies of other heavy metals in treated hospital wastewater are needed before declaring that it is safe.

Conclusion

Treated wastewater in 72 hospitals in 2002

Table 3. Bacteria and parasites identified in treated wastewater (%)

		Samples (n=360)	**Hospitals** (n=72)
Pathogenicbacteria	*Vibrio**	1.9	8.3
	*Salmonella spp.***	1.4	5.6
	Total	3.1	12.5
Opportunistic bacteria	*Aeromonas spp.*	7.8	20.8
	Klebsiella spp.	8.1	18.1
	Pseudomonas spp.	5.3	12.5
	Acinetobacter spp.	1.1	4.2
	Total	20.0	43.1
Parasites*	*Strongyloides stercoralis*	10.0	23.6
	Hookworm	6.4	18.1
	Opisthorchis viverini	3.9	11.1
	Giardia intestinalis	1.4	5.6
	Balatidium coli	2.5	4.2
	Ascaris lumbricoides	0.8	2.8
	Taenia spp.	0.5	2.8
	Fasciolopsis buski	0.3	1.4
	Gnathostoma spinigerum	0.3	1.4
	Total	20.3	41.7

*Vibrio cholerae non-O1/non-O139 4 strains, Vibrio parahemolyticus 1 strain, and unidentified Vibrio species 2 strains
**Salmonella enteritidis gr.G 2 strains, Salmonella enteritidis gr.E 2 strains, and unidentified Salmonella species 1 strain

Table 4. Number of hospitals with microbial comtamination of treated wastewater

Hospital	Total	Contamination		
		Fecalcoliform>1000/100 ml	Pathogenicbacteria	Parasites
University	5	1	0	1
Regional	15	4	1	10
Provincial	25	11	3	7
Community	13	3	2	6
Bangkok Metropolis	4	3	0	1
Armed Forces	3	2	0	0
Private	7	6	3	5
Total	72	30	8	30

Table 5. The concentrations of lead, chromium, and cadmium in treated hospital wastewater (mg/L)

Heavy metals	Treated hospital effluent			**Standard value**		
	Mean	SD	Range	Industrial effluent[8]	Water discharged into irrigation system[9]	Water discharged into deepwells[10]
Lead	0.012	0.007	0.001-0.055	< 0.2	< 0.1	< 0.1
Chromium	0.014	0.011	0.001-0.078	< 0.75*	< 0.3**	< 2.0
Cadmium	0.002	0.002	0.001-0.019	< 0.03	< 0.03	< 0.1

***** Trivalent Chromium, ** Hexavalent Chromium

was contaminated with micro-organisms in two-thirds. Lead, chromium, cadmium in hospital effluent were within standard levels.

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การปนเปื้อนเชื้อก่อโรคและโลหะหนักในน้ำเสียโรงพยาบาลที่บำบัดแล้ว

สมหวัง ด่านชัยวิจิตร, วิชัย วงศ์ชนะภัย, สุสัณห์ อาศนะเสน, ดวงพร จินตโนทัยถาวร

วัตถุประสงค์ : *ศึกษาการปนเปื้อนเชื้อก่อโรคและโลหะหนักในน้ำเสียโรงพยาบาลที่บำบัดแล้ว*

วัสดุและวิธีการ : *วิธีการบำบัดน้ำเสียหาข้อมูลโดยใช้แบบสอบถาม การตรวจความเข้มข้นของคลอรีน, pH, แบคทีเรียและพยาธิในน้ำเสียที่บำบัดแล้วกระทำในโรงพยาบาลที่ศึกษา การตรวจระดับความเข้มข้นของโลหะหนักกระทำโดยวิธี atomic absorption spectrophotometry*

ผลการศึกษา : *ศึกษาในโรงพยาบาล 72 แห่งทั่วประเทศไทย ใน พ.ศ. 2545 วิธีการบำบัดน้ำเสียที่ใช้มากคือ ระบบเร่งตะกอน และระบบคลองวนเวียน พบแบคทีเรียที่มีจำนวนเกินเกณฑ์มาตรฐาน, แบคทีเรียก่อโรค และพยาธิในน้ำเสียที่บำบัดแล้ว จำนวนสองในสามโรงพยาบาล โลหะหนักได้แก่ ตะกั่ว, แคดเมี่ยม, โครเมี่ยม มีระดับอยู่ในเกณฑ์มาตรฐานสำหรับน้ำเสีย*

สรุป : *พบเชื้อจุลชีพเกินเกณฑ์มาตรฐานในน้ำเสียที่บำบัดแล้วของสองในสามของจำนวนโรงพยาบาลที่ศึกษา ระดับตะกั่ว, แคดเมี่ยม และโครเมี่ยมอยู่ในเกณฑ์มาตรฐาน*