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General Characteristics of Hospital Wastewater from Three Different Hospitals in Sri Lanka

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Abstract: The hospital wastewater in Sri Lanka is a particular concern possibly due to the hazardous and toxic nature and its direct discharge into water bodies. Hence, this study focuses the characterization of wastewater generated from hospitals in Sri Lanka to assess the spatial and temporal variations. Wastewater samples were collected monthly from three different hospitals over a period of 3 months and they were tested for quality parameters: pH, temperature, electrical conductivity, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), volatile solids (VS), volatile suspended solids (VSS), biological oxygen demand (BOD_5), chemical oxygen demand (COD), nitrate-N, phosphates and heavy metals. The results revealed that hospital wastewater exceeds the allowable limits of Sri Lankan wastewater discharge standards for many of the parameters. The maximum recorded values for TS, TDS, TSS, VS and VSS were 2658, 560, 314, 126 and 235 mg L^{-1}, respectively. The demonstrated values for BOD_5, COD were falling into a large range, 6-1950 and 130-1183 mg L^{-1}. Nitrate-N and phosphate concentration varied and upper limit were reported as 3696 and 103.74 mg L^{-1}. Apparently, maximum concentration of Cr(VI), Mn and Pb were reported as 0.23, 0.52 and 0.90 mg L^{-1}. Further studies are undertaken to analyze volatile organic compounds (VOCs) and pharmaceuticals.

Keywords: BOD_5, COD, Heavy metals, Pollutants, Water quality

1. Introduction

Wastewater is defined as any water, whose quality has been adversely being abused by anthropogenic influence. This includes liquid waste discharged from domestic homes, industries, hospitals, agricultural and commercial sectors. Many of the pollutants detected in wastewaters are categorized as non-regulated “emerging pollutants” [1]. The contact of this kind of wastewater with the surrounding environment results in adverse effects on the biological balance of aquatic ecosystems, causing imbalance at different trophic levels possibly related to the action of toxic and genotoxic agents and indirectly by eutrophication [2].

Over the last few years, hospital effluent has been gained a significant attention in various countries in the world facing different issues. It is well established that hospitals may consume extensive amount of water in a day, ranging between 400 to 1200 L day^{-1} [3] and consequently, generate equally significant volume of wastewater load. Hospital wastewaters (HWW) are generated in different sectors of a hospital including patient wards, surgery units, laboratories, clinical wards, ICU, laundries and possess a quite variable composition depending on the activities involved [4]. In this context, HWW consist a numerous persistent chemical compounds and complex mixtures of organic matter including pharmaceuticals, radionuclides, detergents, antibiotics, antiseptics, surfactants, solvents, medical drugs, heavy metals, radioactive substances and microorganisms [4-5]. After usage, some of these compounds and non-metabolized drugs excreted by patients are detected in HWW and then, enter the municipal sewer network without preliminary treatment. For this reason, this composition leads to extensive levels of toxicity, genotoxicity and organic load and subsequently, causes an adverse impact on the natural ecosystem and inherent hazard to human health [6].

More recently, a study by Jean et al. [7] showed that 15-20% of medicines utilized in hospitals are potentially bio-accumulative. The HWW reveals the presence of potentially toxic heavy metals such as Hg and Ag as well as chlorinated molecules in high concentrations. Additionally, significant concentrations of COD and BOD_5, 1900 and 700 mg L^{-1}, have been assessed in these effluents [3]. Laundry wastewaters from hospitals were characterized by Kern et al. [8] in Brazil and COD and BOD_5 concentrations were as 477 and 305 mg L^{-1}, respectively, when washing stages were not subdivided. However, when washing steps were subdivided into different stages, the first rinsing was demonstrated higher COD and BOD_5 concentrations, 3343 and 1906 mg L^{-1}, respectively.

Pharmaceutical drugs given to people and to domestic animals including antibiotics, hormones, strong painkillers, tranquilizers, and chemotherapy chemicals given to cancer patients are being measured in surface water, groundwater and drinking water as well. Hospitals discharge plenty of undesired potentially pathogenic propagules including antibiotic resistant bacteria, viruses and may be even prions. As a result, in some developing and industrialized countries, the outbreaks of cholera are periodically reported. Moreover, sewers of hospitals where cholera patients are treated are not always connected to efficient sewage treatment plants, and sometimes municipal sewer networks may not even exist.

One of the major environmental concerns due to hospital effluent is their discharge into urban sewerage systems without adequate treatment. HWW could be negatively affected to the ecological balance and public health. If left untreated, pathological, radiaoactive, pharmaceutical, chemical and infectious components of HWW lead to outbreaks of communicable diseases, diarrhea epidemics, cholera, skin diseases, enteric illness, water contamination and radioactive pollution [3]. On the other hand, HWW sludge from on-site treatment plants are to be carefully managed with the precautions as municipal waste sludge. Such sludge must not be utilized as manure without proper pretreatment for food crops [3].

Most often, conventional treatments have been adopted for HWW, however, they are not properly managed and slightly low removal capacities are achieved even for common parameters including BOD_5, COD, TSS and total coliform [1]. On the other hand, only a simple primary treatment such as primary clarification and prechlorination is applied for hospital effluent, anyhow it is not efficient. Moreover, no treatment is adopted at all and direct discharge of HWW into water bodies is a common practice in the developing world. Sri Lanka is one particular example for direct discharging of HWW into surrounding environment. However, no studies have been carried out to examine the quality of HWW in different contexts. No baseline data available to drive the authorities to have a proper wastewater treatment or management system. Hence, the main aim of this study was to investigate conventional physico-chemical parameters including BOD_5, COD, TSS, N and P compounds, pH and selected heavy metals for hospital effluents collected from different locations in Sri Lanka with an aim of assessing their temporal and spatial variations.

2. Materials and methods

The HWW characterization was conducted from March 2015 to June 2015 with one month time intervals. The HWW samples were collected from the three hospitals, Kandy teaching hospital (latitude 7º 17′ 10″ N and longitude 80º 37′ 53″ E), Diyathalawa base hospital (latitude 6º 48′ 20″ N and longitude 80º 57′ 22″ E) and Badulla general hospital (latitude 6º 59′ 30″ N and longitude 81º 03′ 08″ E), Sri Lanka. The respective locations are designated as KTH, DBH and BGH. Samples were collected at five sampling points with three replicates from each location to ensure standard quality control procedures. The respective sampling points are denoted as KTH-01, KTH-02, KTH-03, KTH-04, KTH-05, DBH-01, DBH-02, DBH-03, DBH-04, DBH-05, BGH-01, BGH-02, BGH-03, BGH-04 and BGH-05. The characterization of the collected HWW samples was performed at field conditions and consequently, transferred into the laboratory environment under 4 ºC. Table 1 summarizes different chemical constituents investigated and the analytical methods used.

3. Results and discussion

Wastewater composition describes the actual quantity of physical, chemical and biological constituents present in the wastewater. Depend upon the concentrations of these constituents, wastewater is categorized as strong, medium or weak. According to the results, average pH values were well within the range of 6 to 8.5 [9] in despite of several sampling points. EC of HWW samples varied within the range of 110 and 1120 μS/cm and the average EC was 434.88 μS/cm.

Table 1: Tested quality parameters in HWW

Constitute	Method
pH	Ross sure-flow combination epoxy body electrode
Temperature	Temperature meter (HANNA)
EC	Conductivity meter (Orion 5 star)
TS	Membrane filter paper techniques
TDS	
TSS	
VS	
VSS	
BOD_5	Winkler method
COD	Spectrophotometer (HACH DRB 200)
Nitrate-N	Cadmium reduction method
Phosphate	Ascorbic acid method
Cr(VI)	1,5 dipenyl carbozide method
Mn	Atomic absorption spectrophotometer (GBC 933)
Pb	

Studying the variations of different solid contents is important from a wastewater management perspective because many recommended standards are focused substantially on solids. Maximum TS value recorded was 2658 mg/L at DBH-02. Average TSS of HWW samples was 31.97 mg/L which is within the maximum tolerance limit (MTL) of 50 mg/L given by central environmental authority (CEA) Sri Lanka [9]. However, the maximum TSS value was recorded as 314 mg/L at KTH-04 which is exceeds the MTL given by the CEA. Additionally, the average value recorded for VS and VSS were 125.6 and 235 mg/L, respectively. TDS values were ranging from 50 to 560 mg/L and the average TDS was reported as 144 mg/L.

Figure 1a shows BOD_5 in the three respective hospitals. According to the CEA guidelines, any water to declare as non-polluted the BOD_5 value must be less than 30 mg/L [9]. The average BOD_5 recorded as 416 mg/L in this study. In the case of COD, most of the HWW samples showed higher values than in the MTL established by CEA, which is 250 mg/L [9]. The average COD for HWW samples was 556 mg/L. The COD for

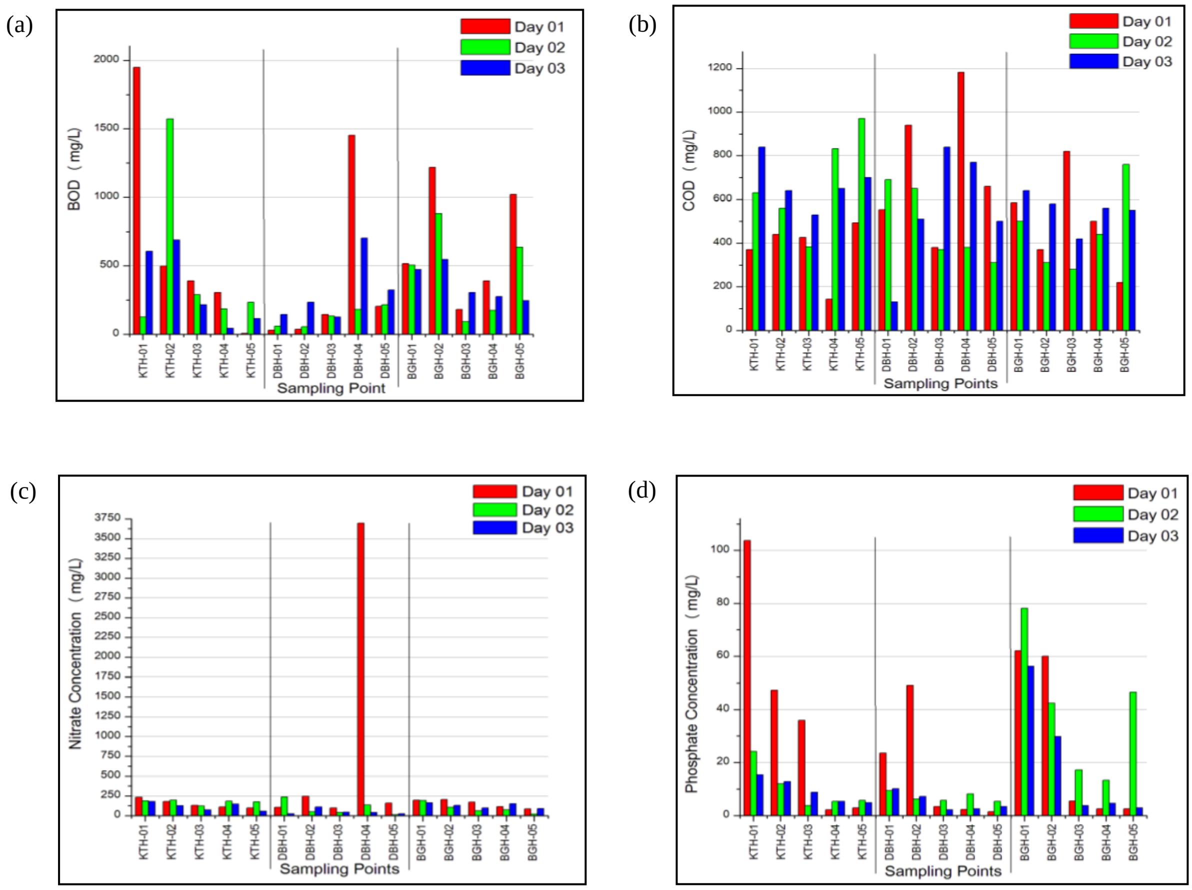

Figure 1: (a) BOD_5 (b) COD (c) nitrate and (d) phosphate concentration in three respective HWW sampling locations

HWW ranged from 130 mg/L to 1183 mg/L (Figure 1b). The higher BOD_5 and COD values can be attributed to the septic matter collected into the drainages and mare of the kitchen waste added into the system.

Among the nutrients, nitrate concentrations were observed in high concentrations ranging from 12 to 3696 mg/L (Figure 1c). Phosphate in the HWW varied in a range of 1.5 to100 mg/L. The average value for phosphate in the samples was 19 mg/L which exceeds the MTL, 5.0 mg/L in wastewater [9]. It is a 381% of increment than the MTL value for wastewater. The maximum phosphate concentration dissolved in the wastewater was 104 mg/L at KTH-01 (Figure 1d). Kitchen and septic waste as well as sodium tri-phosphate (STPP) which is a cleaning liquid used frequently may be the possible sources of phosphate in HWW.

It is known that heavy metals can accumulate via food chain and reach living organisms causing serious effects. Inspection of Fig. 2 (a) and (b) reveals the variation of some selected heavy metal species, Mn and Pb, during study period. The MTL for the Mn is 0.5 mg/L [9]. However, the maximum Mn concentration

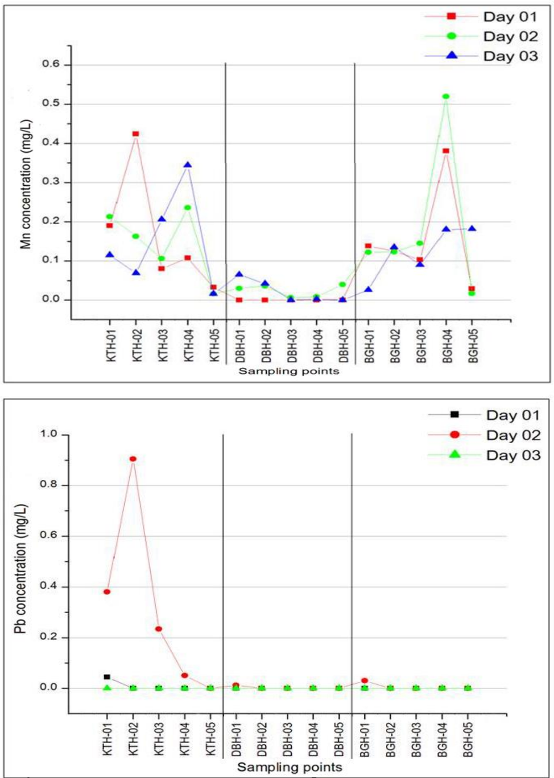

Figure 2: Heavy metal concentrations in different sampling locations (a) Mn (b) Pb

recorded in KTH, DBH and BGH were 0.424, 0.065 and 0.520 mg/L, respectively and only the location BGH exceeds the permissible level. The MTL for the Pb is 0.1 mg/L. The maximum Pb concentration recorded in KTH, DBH and BGH were 0.91, 0.01 and 0.03 mg/L, respectively and among them, KTH exceeds the MTL value nine times higher. Additionally, Cr (VI) concentration varied around 0.01 to 0.225 mg/L. The average value for Cr (VI) concentration was 0.106 mg/L, which is above the maximum tolerance limit, 0.1 mg/L [9] of the wastewater.

4. Conclusions

In summary, this preliminary study describes the physico-chemical composition of HWW discharged from KTH, DBH and BGH, respectively. In fact, this study provides a general overview of the contaminants relative to the spatial and temporal variation of HWW. Accordingly, some solids such as TSS showed a maximum of 314 mg/L was higher exceeding the country's MTL. The demonstrated values for BOD_5, COD, nitrate and phosphate were falling into a large range, exhibiting spatial and temporal complexity and exceeding MTL in most occasions. Additionally, heavy metals including Mn, Pb and Cr(VI) are present in considerable concentrations leading to deleterious effects on living organisms. Thereby, it is seems obvious that suitable management practices should be initiated for HWW treatment making it safe to discharge into the surrounding environment. On the other hand, it is timely needed to investigate VOCs, chlorinated byproducts and pharmaceuticals in HWW since they are capable of adversely affect on human health.

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