*Section A-Research paper*
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# Characterization and Evaluation of Management Practices of Five Hospital Wastewaters in Alwar ,Rajasthan.

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**Abstract**
**Introduction:** Hospitals consume and generate a large volume of hospital wastewaters which is complex in nature as it has a variety of pollutants which need specific treatment before being discharged into the aquatic environment.Hospital wastewater management thus is an integral part of any health care facility.The treatment of any hospital wastewater largely depends on its basic physico-chemical parameters as these tend to interfere with the above.Our study aims to analyse the quality of wastewaters released by the 05 hospitals of the Alwar city and also evaluates the existing wastewater management practices. **Methods:** The study had two sections: our first section was analytical where samples were analysed for physico-chemical and bacteriological parameters. On the obtained results an analysis of variance at significance 0.05 and parameter correlation matrix was performed. In the second section hospital wastewater management aspects were assessed through a questionnaire for which the respondents were serving staff of the chosen health care facilities. **Results:** With regards to physico-chemical variables only the pH values were in agreement with the standard limits, rest all parameters were in the higher range with TSS and COD results showing significant variation($p<0.05$), for the bacteriological analysis both total coliform and faecal coliform were in higher range and had significant variation ($p<0.05$) between the hospitals.The hospital wastewater management practices showed a lacuna in the pretreatment and disposal aspects whereas segregation and collection were in accordance with bio medical waste management rules, 1998. **Conclusion:** The samples of hospital wastewaters were polluted, received no specific treatment and management of wastewaters by the health care facilities was poor.
**Key Words: hospital wastewater, management, physico-chemical, bacteriological, treatment.**

## 1 Introduction

A large proportion of Bio Medical Waste (BMW) is in the form of hospital wastewaters(HWWs). Hospitals consume an important volume of water per day because it is a well-known fact that water is a convenient and universal solvent, which is used to transport waste products away from the site of production and discharge, and thus hospital wastewaters are an incontestable release source of many chemical

compounds[1]. The important point to remember here is that the waste generators are both the patients and the hospital staff consequently large volumes of wastewaters are generated which is usually pathological, infectious and chemically hazardous.As per the BMW M and handling rules 1998, liquid pathological and chemical waste should be pretreated before discharging into municipal sewer. Majority of pathological HWWs are generated from the operation theatres and the maximum amount of infectious wastewater is generated from the wards. Mortuary generates both pathological and infectious HWWs. Thus any HWW M should include the following steps:

i Segregation
ii Collection
iii Treatment
iv Disposal
v Discharge into water bodies[2]

An in-depth literature review has been conducted on conventional pollutants of wastewaters from hospitals.[(3-8)] . Hospital wastewaters significantly change the degree of contamination and pollution loads as compared to sewage water.[9] Thus any health care centre is a major source of two types of pollutants - air and water.Hospitals being major consumers of water generate reciprocally large volumes of waste water which in majority of cases is discharged without any treatment into the aquatic environment or into the municipal sewer system. Though much of the emphasis has been given to the solid BMW, Central Pollution Control Board (CPCB)as per the BMW rules 2016, has issued permissible limits for the discharge of major contaminants present in wastewater yet lacuna exists in the quantity and quality of the liquid discharged and in the efficacy of the adopted treatment options in removing the contaminants. As such this analytical study was planned to analyse the essential parameters such as pH, TSS; which are necessary as they interfere in the wastewater treatment methods[10],BOD,COD and DO which indicate the waste loads on the treatment plants[11], the total coliform and faecal coliform count that indicate the pathogenicity of the effluent.[12] Also in the second half of our study we have tried to highlight the existing HWW M practises followed by the selected 05 hospitals of our city . This is equally essential because it is on this aspect that the results of the various variables present in the wastewater depend[13]. The city has nine sewage treatment plants (STP) but it is a well studied fact that the dilution of HWW in the wastewater treatment plants (WWTPs) i.e. co-treatment greatly affects the removal efficacy of the pollutants as a variety of emerging contaminants are present in the HWWs in micro and nano concentrations making it all the more a highly complex effluent[14].

## 2 Materials and Method

For the analytical part of this study following methodology was adapted:

### 2.1 Study design and area of study

For our study five hospitals of Alwar city were chosen where maximum health care activities of the city are handled.

A- Rajiv Gandhi govt multispeciality 368 bedded hospital
B- Zanana govt 262 bedded hospital
C- Satellite govt Kala Kuan multispeciality 50 bedded hospital
D- Saniya multispeciality private 100 bedded hospital
E- Solanki multispeciality private 100 bedded hospital

Wastewaters are drained into the three chambered underground septic tanks designed to collect, settle and instil organic matter digestion by anaerobic fermentation.

**2.2 Sample sites**

The composite samples of HWW were collected once every month for one year from dec 2021 to dec 2022 from the point where the HWWs meet the municipal sewer,Thus a total of 60 samples were analysed for physico-chemical parameters , for microbial analysis a total of 30 samples were analysed.

**2.3 Sample collection and transportation**

For physicochemical analysis samples were collected in 1L air tight plastic bottles and for microbial analysis 500 ml airtight glass bottles were used. Samples were kept in ice boxes to prevent physical, chemical and biological decomposition. All the samples were analysed within 48 hrs of collection.

**2.4 Sample analysis**

Table 1 shows the methodology adopted for sample analysis

| S No | Variable | Methodology |
|---|---|---|
| 1 | pH | Digital, systronic pH metre |
| 2 | TSS | oven |
| 3 | $BOD_5$ | 5 day titrimetric analysis ,5210(B) |
| 4 | COD | Titrimetric potassium dichromate method, 5220(B) |
| 5 | DO | Iodometric titration |
| 6 | Total coliform bacteria | Method 1604 MI medium |
| 7 | Faecal coliform bacteria | LTB/EC 1680 method |

**2.5 Statistical tools**

The collected data were entered into the computer in the excel datasheets where data analysis was done using microsoft excel functions. The frequency distribution was calculated using descriptive analysis and expressed in the form of mean ± standard deviation. ANOVA was done to assess the similarity/ dissimilarity between the means of the results obtained. $P \leq 0.05$ was considered significant for all statistical analyses. Correlation coefficients for all the chosen parameters such as TSS, DO, BOD, COD, TC and FC were calculated and a correlation matrix was prepared .

For the second part of our study i.e. evaluating the HWW M practices of the chosen 05 hospitals : A cross sectional study was designed where a questionnaire was given to the willing randomly selected 250 respondents which were the working staff of these HCFs i.e. doctors, nursing staff and cleaners. This structured questionnaire had 10 questions regarding HWW M, each question had three options with one option being the most preferred one as per the BMW M rules 1998 ,the answers for each question were summarised in a frequency table and from this the existing HWW M

practices of the city were ascertained.

## 3 Results

### 3.1 Physico-Chemical Characteristics

The results for physico-chemical variables are highlighted in Table 2 and Figure 1. Apart from pH all the other variables had values higher than the permissible limits for discharge of effluents in the environment.

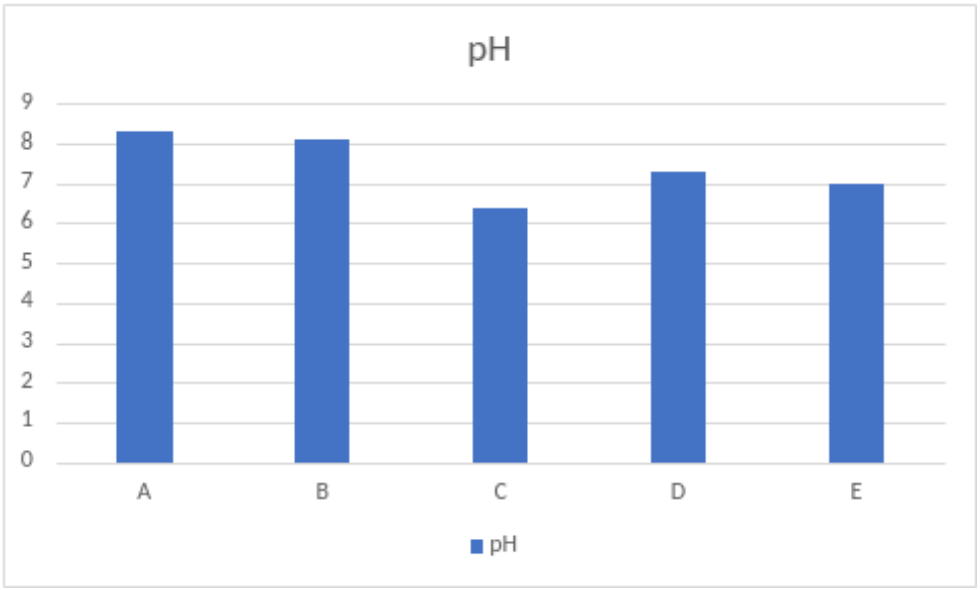


Figure 1 a

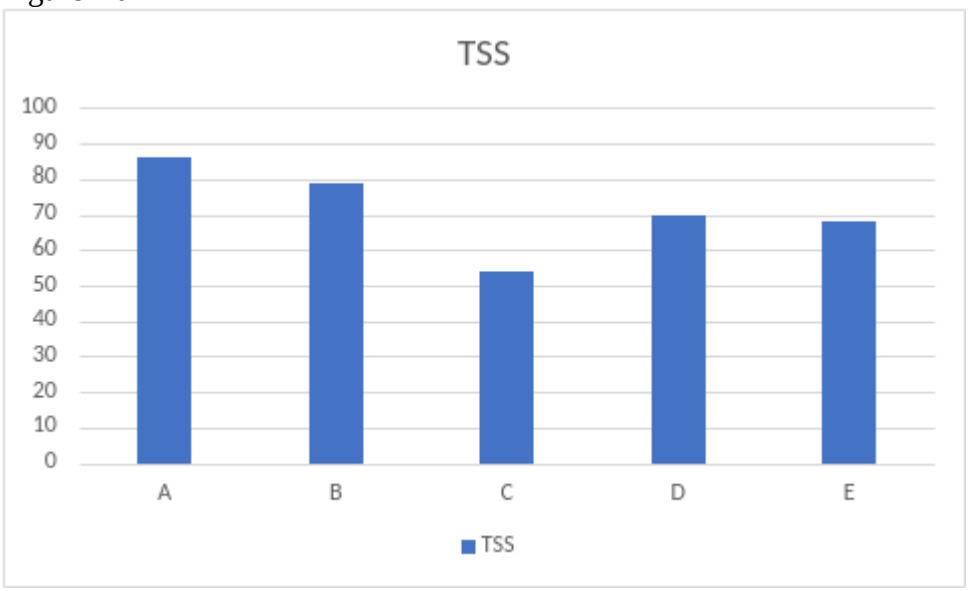


Figure 1 b

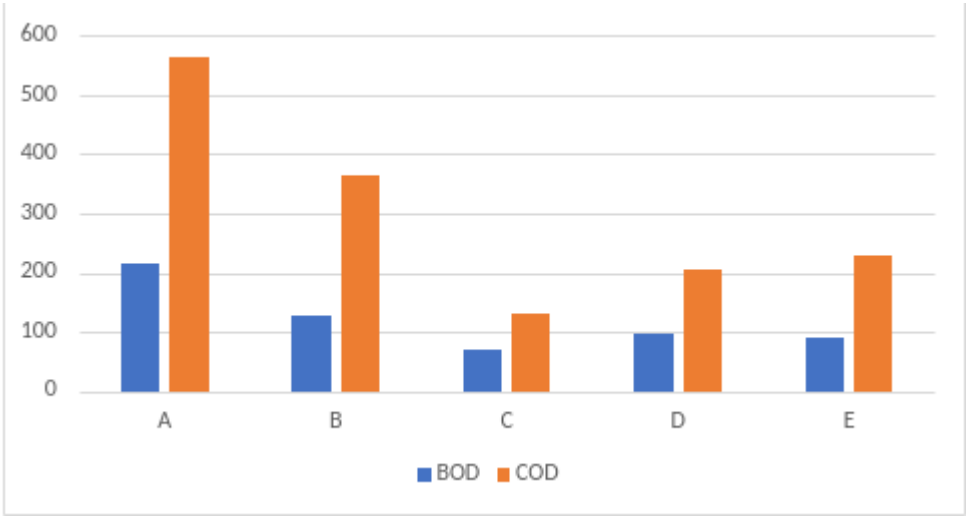


Figure 1 c

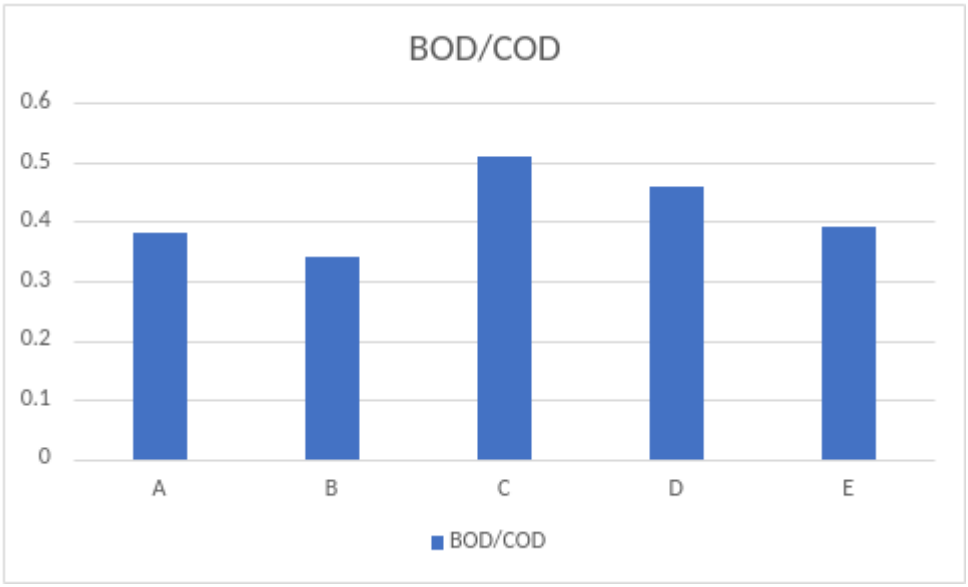


Figure 1 d

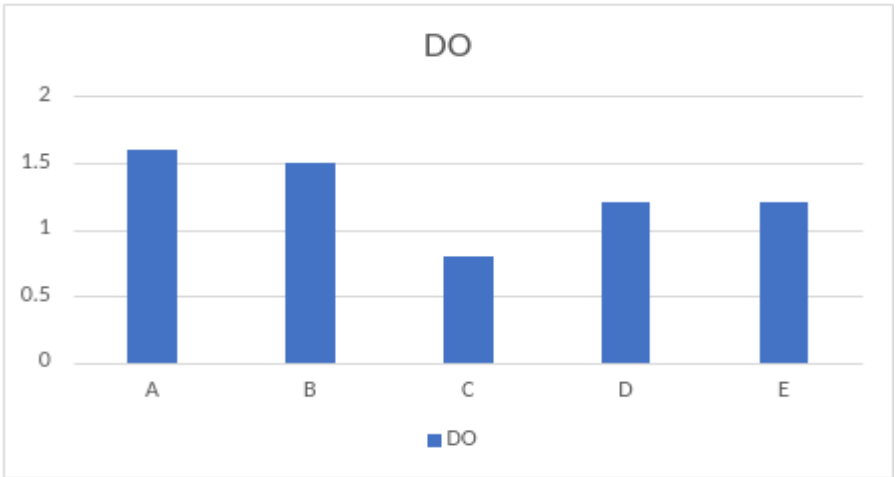


Figure 1 e

Figure 1(a to e) Shows the comparison of the mean values of selected parameters in the 05 hospitals

Table 2 shows the average values for the selected parameters and their permissible standards

| S No | Parameter | No of samples | Min value | Max value | Average | Std dev | P value | permissible limits mg $L^{-1}$ | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CPCB | EPA |
| 1 | pH | 60 | 5.3 | 9.4 | 7.46 | .90 | 5.9 | 5.5-9 | 6-9 |
| 2 | TS**S*** | 60 | 23 | 134 | **71.38** | 19.58 | **0.0004** | 50 | 50 |
| 3 | BOD | 60 | 36 | 345 | **119.01** | 86.90 | 5.5 | 350 | 50 |
| 4 | COD* | 60 | 43 | 987 | **298.71** | 263 | **.0001** | 250 | 250 |
| 5 | DO | 60 | 0.4 | 3.8 | **1.26** | .82 | 0.16 | 1 | 1 |

*Significant difference, TSS: total suspended solids,$BOD_5$: biological oxygen demand, COD: chemical oxygen demand, DO: dissolved oxygen,CPCB: central pollution control board, EPA: environment protection agency.

The results show that the highest values for pH, TSS and BOD is obtained in hospital A and the lowest in hospital C, where as for COD highest values are obtained in hospital A and B and lowest in hospital C and D, for DO highest values are obtained in hospital A and E and lowest in hospital C and D.Among the physico-chemical parameters,significant difference was noted for TSS and COD where a P value < 0.05 was obtained and so a variance between the mean values of TSS for hospital A and C and hospital B and C were observed, for COD similarly variance seen was between the mean values of hospitals A and C, A and D, A and E; the BOD/COD ratio obtained was .41 indicating the low biodegradability of the samples.

**3.2 Bacteriological Characteristics**

Bacteria are the largest microbial community with the longest survival period being for the coliform group in the HWWs and so an analysis of total and faecal coliform bacteria formed an essential part of this study.

The results for bacteriological analysis are shown in Table 3 and Figure 2

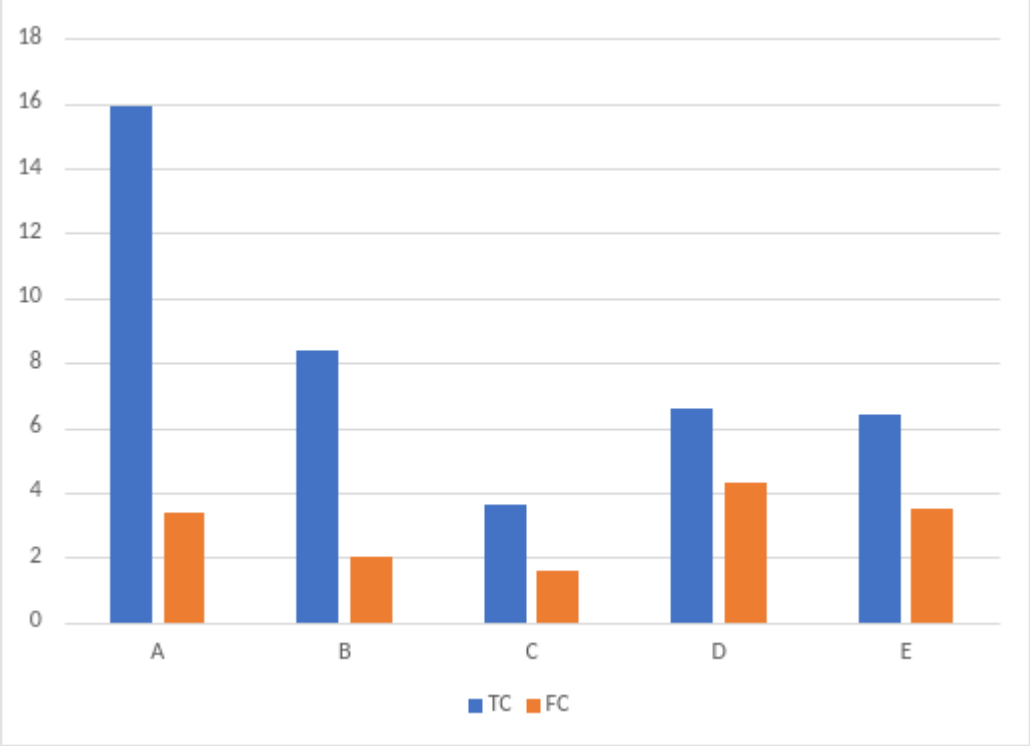


Figure 2 highlights the mean values for TC and FC in CFU/mL in the 05 hospitals

Table 3 shows the average values of bacteriological analysis and permissible limits

| Parameter | Min value | Max value | Mean | Std dev | P value | Permissible limits CFU/ml |
|---|---|---|---|---|---|---|
| TC* bacteria | 3.6 | 15.9 | 8.21 | 5.4 | **.0001** | 4 x$10^2$ |
| FC* bacteria | 1.6 | 4.3 | 3.01 | 1.79 | **.03** | 2 x$10^2$ |

*Significant difference,TC: total coliform, FC: faecal coliform, CFU: colony forming units.

The results for TC and FC show that the highest and lowest number observed were from hospital A and C with a significant difference in mean values of hospital A and B, A and C, A and D, A and E for total coliform and in hospital C and D for faecal coliform bacteria.Thus bacterial load varied significantly across all the selected hospitals. Out of the total coliform 37% were faecal coliform.

**3.3 Correlation between the variables**

A significant and positive correlation was seen between the variables TSS, BOD, COD, DO and TC. Similarly a weak and positive correlation was seen between the above variables for FC.

Table 4 shows the correlation matrix between the global pollutants of HWW

| | TSS | BOD | COD | DO | TC | FC |
|---|---|---|---|---|---|---|
| TSS | 1 | | | | | |
| BOD | 0.89* | 1 | | | | |
| COD | 0.93* | 0.87* | 1 | | | |
| DO | 0.91* | 0.86* | 0.90* | 1 | | |
| TC | 0.90* | 0.99* | 0.97* | 0.85* | 1 | |
| FC | 0.35 | 0.22 | 0.16 | 0.31 | 0.31 | 1 |

*Significant and positive correlation between the variables.

**3.4 HWW M practices**

Table 5 summarises the results for the questionnaire in the form of frequency distribution.

| HWW M practices | Always /Yes n (%) | Sometimes n (%) | never/ No n (%) |
|---|---|---|---|
| Do hospitals consume and discharge a larger vol of water? | 180 (72) | 40 (16) | 30 (12) |
| Is the HWW directly disposed of in municipal sewers?(Co treatment) | 153 (61) | 73 (29) | 24 (10) |
| Is HWW different from domestic wastewater? | 172 (69) | 58 (23) | 20 (8) |
| Is the HWW record maintained? | 43 (17) | 108 (43) | 49 (40) |
| Is HWW segregated? | 183 (73) | 48 (19) | 17 (8) |
| Is any kind of pretreatment given to HWW? | 83 (33) | 93 (37) | 74 (30) |
| Is there any sedimentation tank in the hospital? | 152 (61) | —-- | 98 (39) |
| Are HWWs a rich source of micro pollutants? | 200 (81) | 40 (16) | 10 (4) |
| Are HWWs pathological and infectious? | 178 (71) | 60 (24) | 12 (5) |

| | | | |
|---|---|---|---|
| Any advanced type of ETP installed in the hospital? | 20 (8) | ---- | 230 (92) |

The results highlight that the concerned HCFs have a good practice of segregation and collection of HWWs for which there were separate pipelines through which the wastewaters from different units of the HCF are discharged and were then collected in an underground septic tank. The point where these HCFs are lagging is in the pretreatment and disposal of HWWs.As per the BMW M rules the pathological liquid waste should be pretreated by chemical disinfectants and the chemical liquid waste to be neutralised with reagents. Our observations during regular visits to the hospitals found a lacuna in this practice. Also none of the HCF had an advanced ETP(effluent treatment plant) designed for the removal of micro contaminants which is a must in today's scenario as not only the variety but also the consumption of pharmaceuticals is increasing.

**4 Discussions**

Among the physico- chemical variables all except pH were at a higher range than the standard values. The most critical parameters used to assess the organic / inorganic loads of wastewaters are TSS, BOD and COD[15] and thus a significant and positive correlation between their analytical values was obtained, higher range of values signify increased organic pollution possibly due to high medical activities and low treatment of HWWs[16]. As for the bacteriological analysis this was also found in accordance with the physico-chemical variables as these also did not respect the standard limits.The presence of total coliform and faecal coliform bacteria show that the wastewater are subject to anthropogenic microbiological pollution and direct release of this wastewater i.e. without any pretreatment can pose serious risks of epidemiological outbreak[17]. A positive correlation between total and faecal coliform is well justified because both are indicators of faecal contamination.Also a high number of these bacteria in the HWWs indirectly indicate the presence or absence of antibiotics and disinfectants[18]. Thus with regards to the results obtained for phsico-chemical and bacteriological analysis these are well in accordance with the earlier reported literature[(19-22)]. Regarding the HWW M important issues such as HWW quantity released , specific and advanced treatment methods were missing. This suggests the fact that perhaps solid BMW is being given more importance than liquid BMW which is equally rather more important as this wastewater finally finds its way in an underground water body or is mixed with surface waters.

**Conclusions**

The present study gives a preliminary insight in the wastewater management and characteristics of liquid discharged from health care facilities, though it is lacking in toxicological assessments yet it can be concluded that the hospital wastewaters from the chosen 05 hospitals are of bad quality, posing risks for environmental and human health. Further studies on this topic are needed so that appropriate treatment methods could be adopted. We in our small effort have tried to create awareness regarding this neglected but crucial aspect of HCFs, who hopefully would seriously work upon the installation of ETP in their premises.

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