JAEHR Journal of Advances in Environmental Health Research

# Healthcare waste management and practices: A case study in Kodagu District, Karnataka, India

Harikaranahalli Puttaiah-Shivaraju[1], Behzad Shahmoradi[2]

1 Department of Environmental Science, School of Life Science, J.S.S. University, Shivarathreshwara Nagara, Mysore-570015, India
2 Kurdistan Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran

Original Article

## Abstract

Inappropriate handling and disposal practices of healthcare waste (HCW) at healthcare centers are significantly increasing health and environmental hazards. This paper summarizes the existing situation of HCW handling and management practices at healthcare facilities in Kodagu district (India). This study was conducted for a period of six months using well-designed checklists along with field observations and personal interviews with healthcare workers. Various HCW management issues like quantitative generation, category-wise handling, source level segregation, existing treatment, and disposal methods were studied. Moreover, drawbacks and practices in segregation, collection, transportation, storage, and final disposal methods of HCW in healthcare centers were investigated. The present study showed that lack of knowledge, guilty attitude, negligence of healthcare workers, and poor infrastructure were the major reasons for failure in the HCW handling and management system in the district. In addition to HCW management and infrastructures, associated health and environmental impacts were also discussed. Based on the existing situation and HCW management practices, suggestions and recommendations were made that may ensure the potential HCW handling and management practices and environmental risks minimization.

**KEYWORDS:** Healthcare Waste, Health Hazard, Kodagu District, Environmental Risk, Hospital, Waste Handling Persons, Disposal

***Date of submission:*** 1 June 2013, ***Date of acceptance:*** 2 September 2013

**Citation:** Puttaiah-Shivaraju H, Shahmoradi B. **Healthcare waste management and practices: A case study in Kodagu District, Karnataka, India.** J Adv Environ Health Res 2013; 1(2): 63-72.

## Introduction

Healthcare wastes (HCW) refer to all waste generated by the healthcare establishments such as hospitals, research institutions, clinics, laboratories, blood banks, animal houses, and healthcare teaching institutes. It is estimated that 15-20% of HCW is highly infectious, hazardous, and has the potential for creating a variety of health and environmental risks. Major hospitals contribute substantially large quantity of HCW, smaller hospitals, nursing homes, clinics, pathological laboratories, blood banks, and etcetera also contribute to a substantial amount of infectious wastes which are highly hazardous. Healthcare activities lead to production of large amount of HCW that may lead to adverse effects on human health and their surrounding environment. About 15-20% of infectious waste (such as sharp waste, body part waste, chemical or pharmaceutical waste, and radioactive and cytotoxic waste, broken thermometers, and etcetera) are highly injurious to human beings,

**Corresponding Author:**
*Harikaranahalli Puttaiah-Shivaraju*
*Email: shivarajuenvi@gmail.com*

animals, and the environment.[1-6] Approximately 80-85% of HCW (noninfectious wastes) are non-hazardous and as harmless as any other municipal waste. It is important to realize that if both (noninfectious and infectious wastes) of these two types of HCW are mixed together then the whole waste becomes harmful.[7-11] Sharp wastes, including needles, broken glasses, ampoules, and vials, produced in small quantities are highly infectious and their improper management causes health hazards to healthcare workers, waste handlers, and surrounding communities. In special cases, improper management of infected needles and syringes presents a particular threat to the society through them being reused by unauthorized persons which may spread infection.[3,4] Epidemiological studies indicate that a person who has experienced one needle-stick injury from a used needle has a 30, 1.8, and 0.3% risk of becoming infected with HBV, HCV, and HIV, respectively. In 2004, the results of a WHO assessment conducted in 22 developing countries showed improper disposal of HCW generated in major healthcare facilities in India causing nosocomial infection.[1,12-16] The handling, collection, transportation, storage, and proper disposal of HCW has become a significant concern for both healthcare workers and the public. Since the implementation of biomedical waste handling and management rules in India, every concerned healthcare personnel is expected to have correct knowledge, practice, and capacity to guide others for HCW collection, management, and appropriate handling techniques.[17,18]

The present study aims at exploring the current situation, practices, and drawbacks in the HCW management system in Kodagu District, India. An effort was made to explore the particular reasons for failure in the HCW handling and management system at healthcare facilities in the district. The present study has much scope with respect to environmental impact and HCW management, because the Kodagu is identified as one of the most ecologically rich areas in the country.

## Materials and Methods

The data concerning HCW handling and management practices in Kodagu district, India, was obtained through the hospital records, field observation, hospital survey, and interaction and interviews with healthcare workers, nonclinical workers, and waste handling persons. Photographic evidences were also made related to generation, storage, collection, transportation, treatment, and disposal of HCW. The data were collected using well designed questionnaires for determination of healthcare workers knowledge, attitude, and behavior on HCW handling and management in terms of collection, segregation, transportation, treatment, and disposal. In addition, a survey was conducted for analysis of the HCW management system; for example, in terms of existing practices and drawbacks. In total, 53 important healthcare facilities were selected for the study, including 39 governmental hospitals [30 primary health centers (PHC) of 5-10 beds, 6 community health centers (CHC) of 30-50 beds, 2 Taluk level hospitals (TGH) of 180-200 beds, and 1 district hospital (DGH) of 400-450 beds] and 14 private nursing homes (PNH) of 10-50 beds. Generally, 120 healthcare workers such as doctors, nurses, lab-technicians, pharmacist, and nonclinical/waste handling persons were randomly selected for the personal interviews and interactions.

Kodagu is one of the smallest districts in Karnataka State (South India) comprising of three Taluks (Madikeri, Somwarpet, and Virajpet). The district has an area of 4102 sq. km and 30% of the district is forest area. Its population as per 2011 census is 554,762. The district has a mountainous configuration, which presents a grand panorama of verdant valleys, ravines, fast flowing streams, lofty peaks, and awe inspiring spurs. The major peaks are Tadiandamol, Brahmagiri, and Pushpagiri Hills. Kodagu is a veritable botanist's paradise with more than 1,300 species. The district has a very moist, rainy monsoon climate and most of the

healthcare facilities in the district are located on the river beds or next to the channels which are connected to the river stream. Figure 1 shows the location of healthcare facilities selected for the study in the district.

## Results and Discussion

### Qualitative and Quantitative Study

All categories of HCW described in the biomedical waste (handling and management) rules (Ministry of Forest and Environment, 1998) were generated in all the healthcare facilities in the district. During the study, it was observed that large healthcare facilities like DGH, TGHs, and a few PNHs were generating large quantities of infectious HCW. Qualitative and quantitative data of HCW generated at different levels of healthcare facilities in the district are given in table 1. The present study showed that Cat-1 (anatomical waste) and Cat-4 (sharp waste including needles, broken glasses, ampoules, vials, blades, and etcetera) were the primary and secondary components of HCW generated, respectively, in the district. Moreover, Cat-6 (soiled waste including infected cotton, dressing cloths, bandages, and swabbing materials), Cat-7 (solid wastes including IV bottles, catheters, syringes, intravenous tubes, and etcetera), and Cat-3 (laboratory wastes such as swabs, culture, and culture media) were observed as other major components of HCW generated in most of the healthcare facilities. Other HCW, such as Cat-5 (discarded medicines and drugs), and Cat-10 (chemical waste including pesticides and

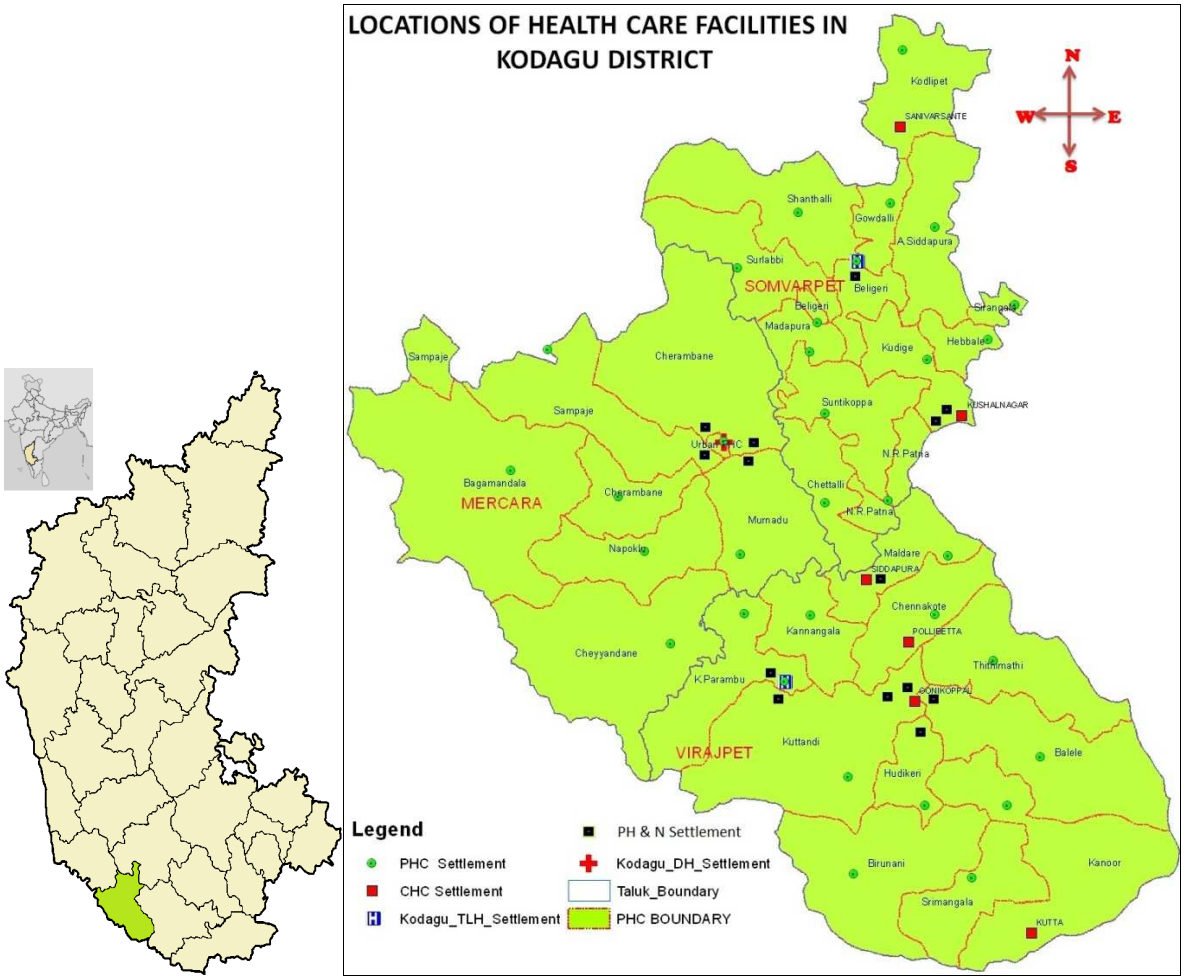


**Figure 1. Major healthcare facilities selected for the healthcare management studies in Kodagu district**

**Table 1. Categories of healthcare wastes (HCW) quantitative generation per day at different level health care facilities in Kodagu district**

| Average HCW generated at different health care facilities in Kodagu district (in kg/day) | | | | |
|---|---|---|---|---|
| | DGH (1) | TGH (2) | CHC (6) & PNH (9) | PHC (29) & PNH (5) |
| Category 1 | 4.20 | 2.80 | 1.45 | 0.72 |
| Category 2 | -- | -- | -- | -- |
| Category 3 | 1.20 | 0.82 | 0.42 | 0.15 |
| Category 4 | 3.38 | 1.20 | 0.66 | 0.50 |
| Category 5 | 0.83 | 0.40 | 0.07 | 0.02 |
| Category 6 | 1.83 | 1.41 | 0.70 | 0.40 |
| Category 7 | 1.40 | 1.03 | 0.67 | 0.01 |
| Category 9 | -- | -- | -- | -- |
| Category 8 | > 2000 L | > 400 L | > 250 | > 120 L |
| Category 10 | 0.15 | 0.05 | -- | -- |

HCW: Healthcare wastes; DGH: District hospital; TGH: Taluk level hospitals; CHC: Community health centers; PHC: Primary health centers PNH: Private nursing homes

insecticides), were occasionally generated as minor components. Generation of large volume of liquid HCW from laboratories, operation theaters, and the delivery section was observed throughout the study. During the investigation, we did not find generation of any considerable quantities of HCW such as Cat-2 (animal wastes) and Cat-10 (incineration ash) at healthcare facilities in the district. Figure 2 shows the percentage of major components in categories of HCW generated at different level healthcare facilities in the district. The results showed that Cat-4 and Cat-7 were the major components of HCW generated, and recycling of such HCW may reduce the environmental risk by resource utilization and waste reduction at the source.

## Handling, Segregation, and Collection

Among the healthcare facilities in the district, about 85.71% (12 PNHs) of private nursing homes and 15.38% (2 CHCS and 4 PHCS) of governmental hospitals were found to have inappropriate practice and management of HCWs. During the study, improper segregation of HCW generated in private nursing homes (12 PNH) and in a few governmental hospitals (2 CHCS and 4 PHCS) in the district was observed. In total, about 33.96% of healthcare facilities in the district had inappropriate segregation and collection of HCW. In such healthcare facilities, all categories of HCWs, including general wastes (noninfectious wastes), were put together using single containers. Due to improper segregation of HCW at the initial stage, 80-85% of noninfectious waste would be converted into infectious waste; this indicates a 4-5 times increased rate of health and environmental risks along with HCW management cost. The study revealed that a few PNHs (57.14%) provided required color coded containers for segregation and collection of HCW, even though waste handling persons were not following standard procedures for segregation and collection of HCW. In the district, two PNHs (14.29%) and 33 governmental hospitals (84.62%) including 1 DGH, 2 TGHs, 4 CHCs, and 25 PHCs appropriately segregated HCWs at initial stages using color coded bins and liners as per the abovementioned standard guidelines. About 25 PHCs (86.20%), located in rural and remote areas in the district, used three color coded containers and liners for segregation and collection of HCW. The placenta (Cat-1) generated, and handed over to the custodian and buried according to the religious rites was reported in 4 PHCs, located in rural areas. At the remaining healthcare facilities (33.96%) in the district, we found inappropriate and inadequate usage of color coded containers for segregation and collection of HCW. Color coding used for segregation and collection of HCW in different healthcare facilities in the district was studied and reported (Table 2). Segregation is an

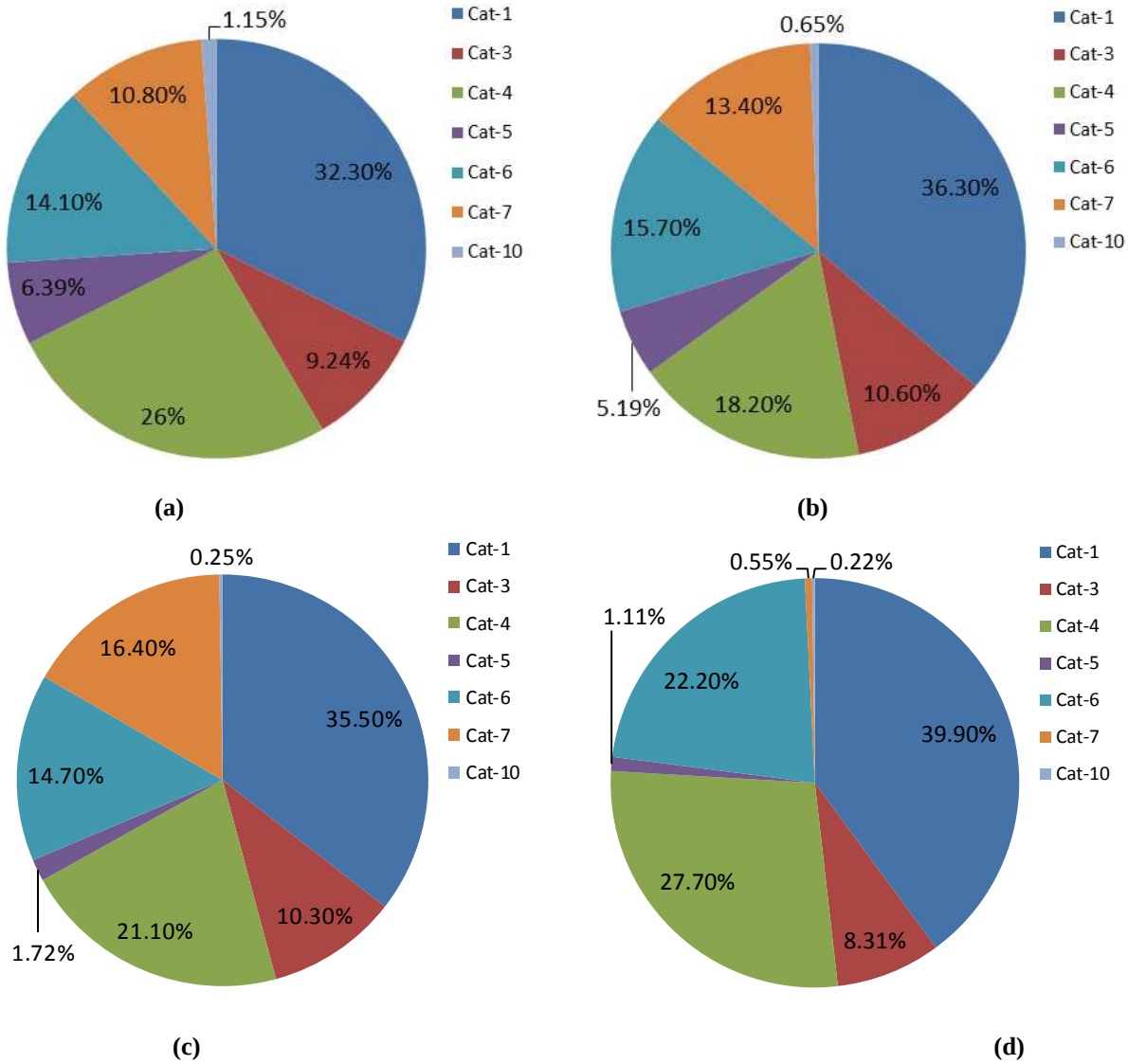


**Figure 2. Important categories of healthcare waste components at different level healthcare facilities in Kodagu district: (a) 400-450 bed facility hospitals; (b) 180-200 bed facility hospitals; (c) 30-50 bed facility hospitals; and (b) 5-10 bed facility hospitals**

**Table 2. Color codes used for segregation and collection of health care wastes generated in different level hospitals in the district**

| Color codes used | DGH, 2 TGHs, 2 PNHs & 4 CHC | 25 PHCs | 2 CHCs, & 4 PHCs |
|---|---|---|---|
| Yellow | Category 1 | Category 1, 3, and 6 | Category 7 |
| Red | Category 3, and 6 | - | - |
| Blue | Category 7 | Category 7 | Category 1, 3, 4, and 6 |
| Black | Category 5, and 8 | - | - |
| Translucent white | Category 4 | Category 4 | Category 4, 7, and 3 |

DGH: District hospital; TGH: Taluk level hospitals; CHC: Community health centers; PHC: Primary health centers
PNH: Private nursing homes

important and appropriate step in HCW management and it is the initial responsibility of each healthcare worker at healthcare facilities during HCW handling and management. Systematic segregation determines the optimal functioning of treatment technology and

potential optimized usage, and also increases the longevity of HCW disposal system. Source segregation reduces HCW management cost, amount of infectious waste, and HCW hazards. Moreover, it enables the better recycling and implanting of a system of disinfection, which reduces the overall health and environmental risk in HCW management system.

### Transportation and Temporary Storage

In major healthcare facilities such as DGH, TGHs, and PNHs, no utilization of any equipment, like trolleys or moving baskets, for internal and external transportation of HCW was found. The transportation equipment, like trolleys or moving baskets, are basic needs for HCW transportation within or outside the hospitals. In all healthcare facilities internal transportation of HCW was carried out manually by waste handling persons using polythene or ordinary bags without any safety measurement. They did not use any separate path or route for internal transportation of infectious HCW, and in some healthcare facilities (61%) transportation of infectious HCW was carried out at day time (i.e., peak hours of crowding and medical activities). Major healthcare facilities, like DGH and TGH, where large amounts of HCW are generated and more transportation activities are expected, should be provided with basic facilities and requirements such as separate path or route, and high quality and safe equipment for transportation of HCW. HCW, segregated and collected using color coded bins, were transported into a temporary storage room located within the hospital premises without any safety measurement. It was also observed that temporary storage facilities in all major healthcare facilities (DGH, 2 TGHs, 2 CHCs, and 2 PNHs) were easily accessed by the public or unauthorized recycling persons. During the study, no separate temporary storage room was found in healthcare facilities and collected HCW was temporarily stored in an open room within the hospital, where public areas, such as toilets, patient wards, and etcetera were situated. HCW segregated and collected at PHCs, was transported to disposal sites at the end of shift or day using plastic containers. Only recyclable plastic wastes were temporarily stored in a separate room after disinfection and mutilation using polythene bags in all the PHCs. The study confirmed that inappropriate and unsafe practices were taking place during the transportation and temporary storage of HCW in the major healthcare facilities, like DGH, TGHs, CHCs, and a few PNHs in the district. In addition, we found that the storage time of HCW in a temporary storage room was between 1-2 weeks, depending on the common treatment agency contracted for off-site transportation and disposal. This was contrary to the biomedical waste handling and management regulation.

### Waste Treatment and Disposal

It was observed that about 64.15% of healthcare facilities including 1 DGH, 2 TGH, 4 CHCs, 2 PNHs, and 25 PHCs, follow the standard treatment procedures such as disinfection, needle burning, and mutilation of solid HCWs. Hypochlorite solution (1%) or bleach solution was used as an effective disinfection reagent in all healthcare facilities in the district. Infected solid wastes like plastics and metal wastes were disinfected and mutilated as per the guidelines, then sent for temporary storage or recycling using plastic containers. Needles generated in the hospitals were burnt using electric burners and disinfected, then sent for temporary storage or recycling using puncture proof translucent white containers. Infected HCW such as anatomical wastes, and soiled wastes were carefully collected using yellow and red colored non-chlorinated polythene bags, respectively, and were sent for disposal. Inappropriate and incomplete disinfection and handling procedures were observed during treatment of HCW in 35.84% of healthcare facilities (12 PNHs and 4 PHCs). The present study revealed that only major healthcare facilities (24.53%) were

handing over the collected and temporarily stored HCW to a common treatment private agency called Shree Consultants, Mysore for off-site disposal. On the other hand, among 24.53% of these hospitals only 16.98% followed standard guidelines for mutilation, disinfection, and color coding with appropriate labeling. The remaining 30.77% of hospitals used chlorinated liners for HCW collection, packing with inappropriate segregation, and labeling. The chlorinated liners and plastic wastes along with HCW were directly burned in the incineration chambers at common treatment facilities (CTF). As a result of inadequate and improper maintenance of incineration temperature in the incineration chambers, the chlorinated liners and plastic wastes will produce a large amount of furans, dioxins, chlorinated ions, and other toxic gaseous compounds which further cause health and environmental hazards.[14-16] Disinfected biodegradable infectious HCW (Cat-1, 3, and 6) and sharp wastes were disposed using well designed deep burial pits and sharp pits, respectively. Schematic diagram of deep burial pit and sharp pit are shown in figure 3. During the study we observed unscientific construction and maintenance of deep burial and sharp pits in 9 PHCs and 3 PNHs. In 7 PHCs, deep burial pits had been constructed near or in wet lands, where infectious pathogen could easily spread and there is a potential of groundwater contamination.

Only about 64.15% of healthcare facilities in the district performed on-site treatment of liquid HCW using small liquid treatment units (LTU). Lapse in the construction and maintenance of LTUs, and also improper disinfection of liquid HCW was observed in a few hospitals (2 CHCs, 3 PNHs, and 3 PHCs). Throughout the study we found inattentiveness to the liquid HCW treatment and its improper management in most healthcare facilities, and irregular disinfection of liquid HCW. These issues were attributed to the lack of awareness, interest, and guilty attitudes in healthcare workers. Release of incomplete and untreated liquid HCW into the drainage or ambient environment will cause health and environmental risk.[4-20] There were no effluent treatment plants for mass treatment at healthcare facilities, where a large volume of liquid HCW is expected to be generated in the district. Moreover, no incinerator was observed while frequent open burning of HCW within the hospital premises was observed. Such conditions can cause air pollution and health risks for healthcare workers, and patients and visitors in the hospitals.[16,18,19]

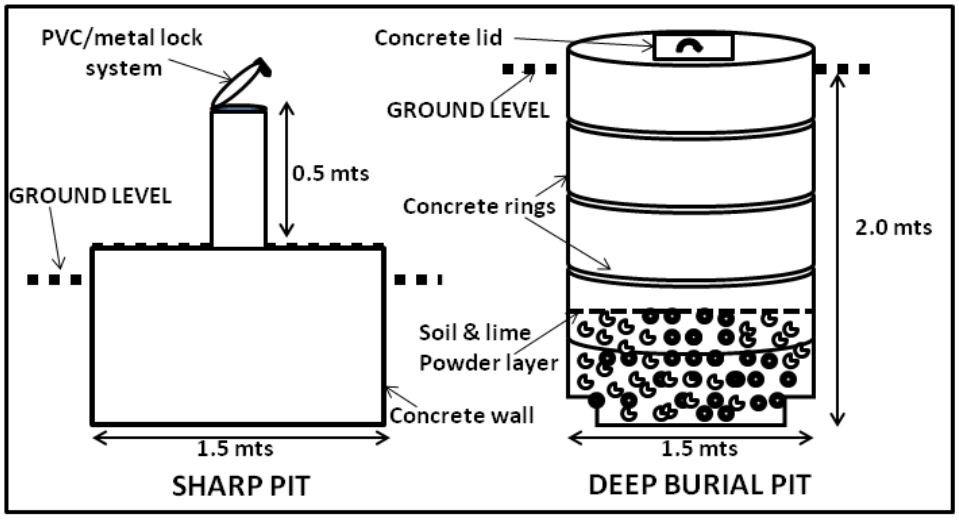


**Figure 3. Schematic diagrams of sharp pit and deep burial pit used for disposal of solid healthcare wastes**

Storage of infectious HCW for a long duration will cause nosocomial infections to healthcare workers, patients, and the surrounding public.[16-20] The lack of adequate and scientific infrastructure for the external transportation (from hospital to CTF) of HCW in the private agency, may cause the spreading of infection throughout the route and cause health risks.[16-20]

## Prophylactic Measures, Knowledge and Awareness

During the study, we found only 2-3% of needle stick injuries were reported in the hospital records. Personal interviews and interactions confirmed that 17.5% (21 persons) of needle stick injuries occurred during HCW handling, but were not reported. The obtained data showed that the proportion of vaccination in healthcare workers was less in the private sectors compared with governmental sectors. Moreover, there were no record of other accidents related to breaking thermometers or overturning of infectious waste containers, splashing of liquid infectious wastes, cross infections, and nosocomial infections by HCW mismanagement in any healthcare facilities in the district, but during our study such accidents were frequently reported by healthcare workers. Moreover, reporting and record keeping related to HCW accidents, needle injuries and nosocomial infections were very poor and not regularly updated. Throughout the study we observed no use of personal protection equipment like utility gloves, protection mask, gum boots, and protection cloth by waste workers during their activities. The study found that handling of sharp and infected wastes in a few PNHs by the nonclinical and waste handling persons was performed with their bare hands. This clearly confirmed the lack of knowledge and awareness on safety measurement and HCW associated risks in low class workers. During the study about 13.33% of doctors were found to have low awareness of HCW management practices, regulations, consequences of HCW on health and environment, and standard regulations to be implemented. About 26.66% of doctors expressed their guilty attitudes and behaviors on HCW management, and also showed the least interest toward systematic management and standard procedure follow-ups during HCW management. About 50 and 66.66% of duty nurses and lab technicians, respectively, had low awareness about and showed low interest in HCW management in their healthcare centers. Among them, 20% and 68% of duty nurses and lab technicians, respectively, showed guilty attitudes and low interest in HCW management. About 80% of nonclinical and waste handling persons regularly involved in cleaning and sanitation works in healthcare centers were found to be completely unaware of HCW management, safety measurement, and HCW associated risks. Only 20% of nonclinical and waste handling persons were moderately aware of HCW and risks associated to it. The least awareness about and interest in HCW management in the district, was observed in the healthcare workers at private hospitals, as compared with the governmental hospitals. About 85 and 8% of healthcare workers (like doctors, nurses, and lab technicians) in governmental and private health sectors, respectively, had joined training and awareness programs on HCW management and regulations.

This study revealed that there were well defined plan or policy, guideline, and definite budget concerning HCW management system in the district, but lack of knowledge, and low awareness and guilty attitudes of healthcare worker might cause inappropriate handling and management practices of HCW.

## Suggestions and Recommendations for the Better Management of HCW

Training programs on scientific handling and management practices of HCW generated, standard regulations and policy should be conducted for all healthcare workers; especially for all the low class workers, like nonclinical/waste handling persons, at

healthcare centers. Private HCW collection agencies should be trained to improve the knowledge about safe and systematic management of HCW. It is suggested that awareness programs, seminars, and capacity buildings (consultation) be conducted for all healthcare workers including doctors, nurses, and lab technicians for improving attitudes and creating positive behaviors toward HCW management. In all the steps of HCW management a labeling and naming system should be introduced, and the local language is suggested for naming and HCW management guidelines. Establishment of a common treatment facility within the district is suggested to avoid delay of disposal of infectious HCW. All healthcare facilities in the district are strongly recommended to dispose of HCW through CTF instead of on-site disposal for environmental pollution remediation in the district. Constructing or equipping major hospitals with suitable wastewater treatment plants is strongly recommended. Moreover, it is suggested to have appropriate management and continuous monitoring of generated HCW, and frequent environmental impact assessment could be performed for better management of HCW and to avoid associated risks on health and environment.

## Conclusion

The current study revealed that there are inappropriate practices in segregation, collection, and transportation in the HCW management system in Kodagu District, Mysore, India. This study explored the major drawbacks in infrastructures and facilities for the collection, transportation, temporary storage, and disposal of HCW. The present study showed that the lack of knowledge, low awareness, and guilty attitudes in healthcare workers on HCW management, and inadequate service provided by private agencies are the drawbacks in HCW management system in the district. The study confirmed the lower knowledge and awareness on HCW and safety measurement in nonclinical/waste handling persons (lower class workers) in healthcare centers when compared with higher class healthcare workers. Qualitative and quantitative generation of HCW at different level healthcare centers were determined and discussed.

## Conflict of Interests

Authors have no conflict of interests.

## References

1. Safe health-care waste management: Policy paper [Online]. [cited 2004]; Available from: URL: http://www.who.int/water_sanitation_health/medicalwaste/hcwmpolicy/en/hcwmpolicye.pdf
2. Rutala WA, Weber DJ. Disinfection, sterilization, and control of hospital waste. In: Mandell GL, Bennett GE, Dolin R, Editors. Principles and Practice of Infectious Diseases. 6th ed. Philadelphia, PA: Elsevier Science Health Science Division; 2004. p. 3331-47.
3. Murthy PG, Leelaja BC, Hosmani SP. Bio-medical wastes disposal and management in some major hospitals of Mysore City, India. International NGO Journal 2011; 6: 71-8.
4. Pandit NB, Mehta HK, Kartha GP, Choudhary SK. Management of bio-medical waste: awareness and practices in a district of Gujarat. Indian J Public Health 2005; 49(4): 245-7.
5. Razdan P, Heema AS. Bio-medical waste management system. ASCNT 2009; 26-31.
6. World Health Organization. Management of waste from hospitals and other health care establishments. Euro Report sand Studies 1985; 97: 1-61.
7. Central pollution control board, Environmental standard and guidelines for management of hospital waste. New Delhi, India: Pollution Control Board; 1996.
8. Pasupathi P, Sindhu S, Ponnusha BS, Ambika A. Biomedical waste management for health care industry. Int J Biol Med Res 2011; 2(1): 472-86.
9. Horsted-Bindslev P. Amalgam toxicity--environmental and occupational hazards. J Dent 2004; 32(5): 359-65.
10. Bansal M, Mishra A, Gautam P, Changulani R, Srivastava D, Singh Gour N. biomedical waste management: awareness and practices in a district of Madhya Pradesh. National Journal of Community Medicine V 2011; 2(3): 452-6.
11. Mathur V, Dwivedi S, Hassan M, Misra R. Knowledge, Attitude, and Practices about Biomedical Waste Management among Healthcare Personnel: A Cross-sectional Study. Indian J Community Med 2011; 36(2): 143-5.

12. Yadavannavar MC, Berad AS, Jagirdar PB. Biomedical Waste Management: A Study of Knowledge, Attitude, and Practices in a Tertiary Health Care Institution in Bijapur. Indian J Community Med 2010; 35(1): 170-1.
13. Rao PH. Report: Hospital waste management--awareness and practices: a study of three states in India. Waste Manag Res 2008; 26(3): 297-303.
14. Aurora CV, Bulucea AV, Bulucea MC, Popescu AF. Assessment of Biomedical Waste Situation in Hospitals of Dolj District. International Journal of Biology and Biomedical Engineering 2008; 1(2): 19-28.
15. Obekpa Abah S, Ige Ohimain E. Healthcare waste management in Nigeria: A case study. Journal of Public Health and Epidemiology 2011; 3(3): 99-110.
16. Abah SO, Ohimain EI. Assessment of dumpsite rehabilitation potential using the integrated risk based approach: a case study of Eneka, Nigeria. World Applied Sciences Journal 2010; 8(4): 436-42.
17. Ministry of environment and forests. [Online]. [cited 1998]; Available from: URL: http://www.envfor.nic.in/legis/hsm/biomed.html
18. Singh IB, Sarma RK. Hospital waste disposal system & technology. J Acad Hosp Adm 1996; 8-9(2-1): 33-9.
19. World Health Organization. Managing Medical Wastes in Developing Countries. Geneva, Switzerland: WHO; 1994.
20. Lakbala P, Mahesh TM. Bio-medical waste management in Shiraz city of Iran. In J Inst Town Plann 2011; 56: 1-8.