Abstract

Health-care waste contains potentially harmful microorganisms and compounds which can infect and affect hospital patients, healthcare workers, the general public and environment. Therefore, management of health care waste requires safe handling, treatment and disposal procedures. While incineration reduces the volume and quantity of waste for final disposal, it leads to the production of fly and bottom ashes laden with toxic incomplete combustion products such as Polycyclic Aromatic Hydrocarbons (PAHs), dioxins, furans and heavy metals. This exposes workers who handle and dispose the bottom ashes, hospital patients, the general public and environment. The goal of this study was to determine the total and individual levels of 16 most prevalent and toxic PAHs. Bottom ash samples were collected from incinerators in five county hospitals in Kenya, namely; Moi-Voi, Narok, Kitale, Makindu and Isiolo. Bottom ash samples were collected over a period of six months from the five hospitals. The samples were then sieved, homogenised and stored at 4˚C in amber coloured glass containers. The PAHs were extracted using 30 ml of a hexane-acetone solvent (1:1) mixture by ultrasonication at room temperature (23˚C) for 45 minutes. The PAHs were then analyzed with a GC-MS spectrophotometer model (Shimadzu GCMS-QP2010 SE) connected to a computer work station was used for the PAHs analysis. The GC-MS was equipped with an SGE BPX5 GC capillary column (30 m × 0.25 mm × 0.25 µm) for the separation of compounds. Helium was used as the carrier gas at a flow rate of 15.5 ml/minute and 14.5 psi. 1 µl of the sample was injected at 280˚C, split mode (10:1). The oven programming was set for a total runtime of 40 minutes, which included: 100˚C (2-minute hold); 10˚C /min rise to 200˚C; 7˚C /min rise to 249˚C; 3˚C /min rise to 300˚C (2-minute hold). The interface temperature was set at 290˚C. Analysis was done in Selected Ion Monitoring (SIM) mode and the peak areas of each of the PAHs were collected from the chromatograph and used for quantification of the 16 PAHs listed by the U.S. Environmental Protection Agency (EPA) which included, BaA (benz[a]anthracene: 4 rings), BaP (benzo[a]pyrene: 5 rings), BbF (benzo [b]fluoranthene: 5 rings), BkF (benzo[k]fluoranthene: 5 rings), Chr (chrysene: 4 rings), DbA (dibenz[a,h]anthracene: 5 rings), InP (indeno[1,2,3 - cd] pyrene: 6 rings) and Acp (acenaphthene: 3 rings), Acpy (acenaphthylene: 3 rings), Ant (anthracene: 3 rings), BghiP (benzo[g,h,i]perylene: 6 rings), Flu (fluorene: 3 rings), FluA (fluoranthene: 4 rings), Nap (naphthalene: 2 rings), PhA (phenanthrene: 3 rings) and Pyr (pyrene: 4 rings). Ion source-interface temperature was set at 200˚C - 250˚C. Internal standards from Sigma Aldrich were used in the analysis and the acquired mass spectra

data were then matched against the NIST 2014 library [1] [2]. The mean PAHs concentration in the bottom ashes of each hospital varied broadly from 0.001 mg/kg to 0.4845 mg/kg, and the mean total concentration levels of individual PAHs ranged from 0.0072 mg/kg to 1.171 mg/kg. Low molecular weight PAHs (Phenanthrene, Naphthalene and Fluorene) were predominant in all the hospital wastes whereas Kitale and Narok presented the lowest PAHs concentrations and the lowest number of individual PAHs. Moi/Voi recorded the highest total PAHs concentration at 1.3129 ± 0.0023 mg/kg from a total of 11 PAHs being detected from the bottom ash samples. Narok had only three PAHs being detected at very low concentrations of 0.0041 ± 0.00 mg/kg, 0.0076 ± 0.00 mg/kg and 0.012 ± 0.00 mg/kg for phenanthrene, anthracene and chrysene respectively. This study presents hospital incinerator bottom ash as containing detectable levels of both carcinogenic and non-carcinogenic PAHs. Continued unprotected exposure of hospital workers (waste handlers) to the bottom ash PAHs could be hazardous to their health because of their cumulative effect. Preventive measures e.g. the use of Personal protective equipment (PPE) should be prioritised to minimise direct contact with the bottom ash. The study recommends an upgrade on incinerator technology for efficient combustion processes thus for better pollution control.