Management of a Hospıtal Wastes Located in Izmir

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Abstract: In this study, the solid wastes produced from a hospital and the present waste management procedures were investigated. The management of solid wastes of the hospital were discussed and some novel waste management techniques were determined to treat the solid wastes. The solid wastes should be collected in special coloured bags, they should be labelled and should be stored in special storage area, and should be disposed by the licensed companies according to Waste Management Regulation. The application of the waste separation at the source throughout the hospital decreases the waste disposal fees. The management of hazardous wastes coming from the hospital should be handled as proposed by the Waste Management Regulations.

Keywords: Hospital solid waste management, Regulation.

1. INTRODUCTION

The aim of this study is to characterise the solid wastes released from a hospital located near İzmir in the Aegean Region, to examine the current solid waste treatment processes present in the hospital, to propose new, advanced solid and waste management treatment process/processes to minimize the wastes released from the hospital for the removal of the pollutants from the wastes for a 'zero discharge' approach.

In the framework of this study,

firstly, the characterization of the solid wastes was performed in the hospital,

secondly, the solid waste removal techniques utilised in the hospital were examined,

thirdly, some new, advanced treatment alternatives are recommended for the treatment of the solid wastes produced from the hospital,

Hospitals are medical institutions that are present in every country and they are essential for human survival [1-7] As they fulfill their duties, hospitals generate dangerous waste materials. While mostly being small in volume, these waste materials may be extremely dangerous for human and environmental well-being [8,9]. Medical waste has four subcategories; domestic, medical, hazardous and radioactive [10]. Domestic waste is generated in the largest quantity from administrative activities, cooking, etc. This type of waste does not require special attention and can be handled by the same way as regular municipal wastes. However, these wastes should be always separated from the other waste types in a hospital to prevent the contamination of domestic waste. Waste may be treated physically, chemically, biologically or by using some advanced methods. Optimal treatment should be used to allow the necessary treatment to the required level. However, over-treatment would bring more material, energy and labor costs. Therefore, the choise of a correct and economic treatment method is essential. Hospital wastes can be solid or liquid. For both these groups, attention is required for their specific source type.

For Turkish hospitals, current regulations impose the treatment of wastes by licensed treatment facilities. Hospitals gather their liquid and solid wastes from their units and store them for a limited time. According to waste class, hospital wastes were sent directly to licensed treatment centers without any pre-treatment on-site. The hospitals need to reserve spaces for storage of the wastes and they have to pay fees to treatment companies. From an environmental perspective, mix-ups or spillages can occur due to the lack of storage space or during transportation of wastes. Moreover, transportation of wastes means carbon emissions. All these problems could be solved by incorporating the on-site treatment facilities in hospitals and by pre-treating the hazardous and medical wastes. However, according to the legislation, it is not possible to establish the incineration or sterilization facilities on site of the hospitals. Currently, the solid wastes released from the hospitals are hazardous wastes, medical wastes, domestic wastes, paper-cardboard wastse, plastic wastes, metal wastes, glass wastes, battery wastes, electronic waste and wood wastes. At the moment, all the aforementioned wastes were to be collected and transported according to procedure prescribed by Waste Management Regulation, [11]. Although food wastes and packaging wastes did not provide a threat to human health; they

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can be dangerous for environment. These wastes mainly consist of uncontaminated waste produced in the kitchen, toilet, garden or administrative facilities. Collected domestic wastes are transported to the disposal points according to the Waste Management Regulation [11]. If the domestic or packaging waste was mixed with medical wastes, these wastes are managed as medical waste and according to Medical Wastes Control Regulation [10]. The pharmaceutical wastes like drugs, expired drugs and antibiotics, genotoxic wastes, and chemical wastes are managed according to the to Medical Wastes Control Regulation [10] and Waste Management Regulation [11]. Waste batteries in the accumulators are collected according to Waste Batteries and Accumulators Control Regulation [12].

Inadequate and improper management of medical wastes may have serious public health consequences and a significant impact on the environment [13]. Injuries can occur when the syringe-needles or the other sharps have not been collected during the handling of wastes in rigid puncture proof containers. Inappropriate design and/or overflow of existing sharps in the containers and unprotected pits increase the risk exposure of the health care workers, of the waste handlers and of the community to needle stick injuries. When hazardous health care wastes are not properly managed, exposure to them could lead to infections, infertility, to genital deformities, to hormonally triggered cancers, to mutagenicity, to dermatitis, to asthma and toneurological disorders in children such as typho, cholera, hepatitis, AIDS and other viral infections through sharps contaminated with blood [14].

The reuse of infectious syringes represents a major threat to public health. Epidemiological studies indicate that a person who experiences needle-stick injury from a needle used on an infected source, the patients have risks of 30%, 1.8%, and 0.3% to become infected with HBV, H CV and HIV, respectively [15]. WHO estimated that injections undertaken with contaminated syringes caused about 23 million infections of Hepatitis B, Hepatitis C and HIV [16].

Chemical and pharmaceutical wastes have toxic, genotoxic, corrosive and flammable properties. These are found in small amounts in the medical wastes. They cause poisoning and damage to the skin, eyes and to the mucous membranes in exposed people. The most common damage is burning of the skin. Water pollution is caused by the mixing of chemical and pharmaceutical wastes into the water during the disposal phase and this creates an adverse effect on the ecosystem. Antibiotics, various drugs, heavy metals, antiseptics have irreversible effects on the ecosystem [17].

The aforementioned situations are very likely to happen when health-care wastes is dumped on un-controlled sites where it can be easily accessed by the public. Particularly, the children are at risk when thet are in contact with infectious wastes. The contact with toxic chemicals, such as disinfectants may cause accidents when they are accessible to the public. In 2002, the results of a WHO assessment conducted in 22 developing countries showed that the proportion of health care facilities that do not use proper waste disposal methods range from 18% up to 64% [17]. In addition to health risks, some direct contact with the health-care wastes can adversely affect the human health by contaminating the water bodies during waste treatment and by polluting the air through emissions of highly toxic gases during incineration. When the wastes that are disposed are not lined or are too close to the water sources, the water bodies may become contaminated. If health-care wastes were burned open to the atmosphere or in an incinerator with no emission control (which is the case with the majority of incinerators in developing countries), dioxins and furans and other toxics air pollutants may be produced. This would cause serious illness in people who inhale this air. When selecting a treatment and or disposal method for HCW, the environmental viability is thus a crucial criteria. WHO has established tolerable intake limits for dioxins and furans, but not for emissions [17]. The latter must be set within the national context. A number of countries have defined emission limits. They range from 0.1 ng TEQ/m3 (Toxicity) up to 0.1 ng to 5 ng TEQ/m3 in Japan, according to incinerator capacity (Immunization, Vaccines and Biologicals (IVB)(Protection of the Human Environment Water, Sanitation and Health (WSH) [18].

In the world, the hospital wastes were separately treated by advanced treatment processes so that the micropollutants and energetic organics can be ultimately removed. In Turkey, the hospital wastewaters were discharged directly into the municipal sewage channel system. The conventional treatment processes used in the treatment of municipal wastewater cannot remove the toxic, energetic, micropollutants and the pharmaceuticals (antibiotics, analgesics, anesthetic chemicals, anti-inflammatories, cytotoxic and cytostatic chemicals, β-Blockers, etc.) used in the hospitals. Therefore, the direct discharges

Table 1: Raw Wastewater Characteristics of the Investigated Hospital

Raw Wastewater Influent Characteristics of the Investigated Hospital	
COD (mg/L)	250
NH_3 (mg/L)	25
NO_3-N (mg/L)	17.93
PO_4-P (mg/L)	12
Total Nitrogen (TN) (mg/L)	33
Total Suspended Solid (TSS) (mg/L)	398
Conductivity (µS/cm)	5
SAR_d (mg/L)	3
Boron (B) (mg/L)	2.3
Sodium (Na) (mg/L)	25
Chlorine (Cl) (mg/L)	1000
Coliform (cfu/mL)	20000
EC (dS/m)	2.1
Total Dissolved Solids (TDS) (mg/L)	500
Total Suspended Solids (TSS) (mg/L)	980
HCO_3 (mg/L)	12
RSC	3.5
SSP	200
ESP	120
pH	8
Aluminum (Al) (mg/L)	2
Arsenic (As) (mg/L)	1
Beryllium (Be) (mg/L)	1.2
Boron (B) (mg/L)	2.3
Cadmium (Cd) (mg/L)	1.6
Chromium (Cr) (mg/L)	2.2
Cobalt (Co) (mg/L)	2.4
Copper (Cu) (mg/L)	3
Flourine (F) (mg/L)	3.6
Iron (Fe) (mg/L)	2.5
Lead (Pb) (mg/L)	2
Lithium (Li) (mg/L)	1.8
Manganese (Mn) (mg/L)	4
Molybdenum (Mo) (mg/L)	1.3
Nickel (Ni) (mg/L)	2.4
Selenium (Se) (mg/L)	1.6
Vanadium (V) (mg/L)	0.9
Zinc (Zn) (mg/L)	3.4

of these chemicals to the municipal treatment reduce the treatment efficiencies of the biological treatment stage in the municipal treatment processes. Therefore, some advanced processes should be used in the treatment of hospital wastes.

As we mentioned above, in the studied hospital although some regulations are present, they were not running in a serious framework advised by the authorities and by the regulations. All the hospital stuff was not informed about the rules of the regulations. Incineration was not applied to all hazardous waste types. Domestic and packacing wastes were temporarly collected and they were not labeled sometimes. The hazardous wastes and the medicals were not collected by the licenced firms. The wastewater of the investigated hospital is currently

Table 2: Limits for the Chemical Quality of Irrigation Water (Regulation for Treated Wastewater to be Used as Irrigation Water and Guidelines for Interpretations of Irrigation Water Quality [19, 20]

Potential irrigation problem	Unit		Degree of restriction on use		
			None	Slight to moderate	Severe
Salinity (affects crop water availability)					
EC_w	dS/m		< 0.7	0.7-3.0	> 3.0
TDS	mg/L		< 450	450-2,000	> 2,000
Infiltration (affects infiltration rate of water-into the soil. Evaluate using EC_w and SAR together)					
SAR	= 0-3	EC_w	= > 0.7	0.7-0.2	< 0.2
	= 3-6		=> 1.2	1.2-0.3	< 0.3
	= 6-12		=> 1.9	1.9-0.5	<0.5
	= 12-20		= > 2.9	2.9- 1.3	<1.3
	= 20-40		=> 5.0	5.0- 2.9	<2.9
Specific ion toxicity (affects sensitive crops).					
Sodium (Na).					
Surface irrigation Sprinkler-irrigation	SAR me/L		< 3 < 3	3-9 > 3	> 9
Chloride (Cl)					
Surface irrigation	mg/L		<140	140-350	> 350
Sprinkler-irrigation	mg/L		< 100	> 100	
Boron (B)	mg/L		< 0.7	0.7-3.0	> 3.0
Miscellaneous effects (affects susceptible crops)					
Nitrogen (NO_3-N)	mg/L		< 5	5-30	> 30
Bicarbonate (HCO_3) (overhead sprinkling only)	me/L		< 1.5	1.5-8.5	m > 8.5
Other parameters for sodium toxicity					
RSC			< 0	0- 1	> 1
SSP			< 60	60-80	> 80
ESP			2-10	10-40	> 40
pH			Normal range	6.5-8.4	

discharged into the municipal sewage system without any pretreatment process.

The pollutant parameters in the hospital wastewaters is shown in Table **1** and the discharge limits for the hospital are given in Table **2**. However, as is known, the hospital wastewater contains many macro and micro-pollutant sources and they are discharged into to the sewerage of the municipal treatment system without treating the harmfull toxic materials. In addition, some pollutant parameters present in the hospital wastewater is given in Table **3**, ana they do not meet with the municipal discharge limits given in Table **2**.

Total Dissolved Solid (TDS) is a measurement of inorganic salts, organic matter and other dissolved materials in water [21]. Water with total dissolved solids concentrations greater than 1000 mg/ L is considered to be “brackish”. Changes in TDS concentrations in waters often result from industrial effluent and this changes the water balance by limiting the inflow, and by increasing the precipitation, or by salt-water intrusion. Total dissolved solids cause toxicity through increase in salinity, changes in the ionic composition of the water and toxicity of individual ions. Increases in salinity have been shown to cause shifts in biotic communities, limit biodiversity, exclude less-tolerant species and cause acute or chronic effects to the specific organisms [21]. EC is the measure of water capacity to conduct electrical current [22]. EC and TDS are water quality parameters which indicate the level of salinity. TDS concentration is a principal pollutant

Table 3: Maximum Permissible Concentrations of Heavy Metals and Toxic Elements in Irrigation Waters (Regulation for Treated Wastewater to be Used as Irrigation Water, and Guidelines for Interpretations of Irrigation Water Quality) [19, 20]

Elements	*Maximum total concentration to the unit area (kg/ha)*	*Maximum allowed concentrations*	
		Limit values for irrigation (mg/L)	*In the areas containing aluminium with pH values between 6.0 and 8.5 when the irrigation duration is low than 24 years (mg/L)*
Al	4,600	5.0	20.0
As	90	0.1	2.0
Be	90	0.1	0.5
Boron (B)	680	3	2.0
Cd (Cadmium)	9	0.01	0.05
Chrom (Cr)	90	0.1	1.0
Cobalt (Co)	45	0.05	5.0
Copper (Cu)	190	0.2	5.0
Floroid (F)	920	1.0	15.0
Iron (Fe)	4,600	5.0	20.0
Lead (Pb)	4,600	5.0	10.0
Lithium (Li)	-	2.5	2.5
Manganese (Mn)	920	0.2	10.0
Molybdenum (Mo)	9	0.0l	0.052
Nickel(Ni)	920	0.2	2.0
Selenium (Se)	16	0.02	0.02
Vanadium (V)	-	0.1	1.0
Zinc (Zn)	1,840	2.0	10.0

because it can explain the water quality in a more complex manner than the EC value [23]. Heavy metals, also known as trace metals, are one of the most persistent pollutants in wastewater. The discharge of high amounts of heavy metals into water bodies leads to several environmental and health impacts. The exposure of humans to heavy metals can occur through a variety of routes, which include inhalation as dust or fume, vaporisation and ingestion through food and drink. Some negative impacts of heavy metals to aquatic ecosystems include death of aquatic life, algal blooms, habitat destruction from sedimentation, debris, increased water flow, other short and long term toxicity from chemical contaminants.

The most common toxic heavy metals in wastewater include arsenic, lead, mercury, cadmium, chromium, copper, nickel, silver, and zinc. The release of high amounts of heavy metals into water bodies creates serious health and environmental problems and may lead to an upsurge in the cost of the wastewater treatment [24,25]. The persistence of heavy metals in wastewater is due to their non-biodegradable and toxic nature[26]. Some of the negative impacts of heavy metals on plants include decrease of seed germination and lipid content by cadmium, decrease in the enzyme activity and plant growth by Chromium, inhibition of the photosynthesis by copper and mercury. The reduction of seed germination by nickel and the reduction of chlorophyll production and plant growth by lead were also detected [27]. The impacts on animals include the reduction of growth and development of cancer, organ damage, nervous damage and in extreme cases, death [28]. The contact of heavy metals in polluted wastewater effluents on humans may be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic [29]. Athough it is reported that individual metals exhibit specific signs of their toxicity, the signs associated with cadmium, lead, arsenic, mercury, zinc, copper and aluminium are cause to some gastrointestinal disorders such as diarrhea, stomatitis, tremor, hemoglobinuria causing a rust-red colour to stool, ataxia, paralysis, vomiting and convulsion. Depression and pneumonia can occur when volatile vapours are inhaled [30,31]. High COD concentrations

cause the depletion of oxygen in the aquatic ecocystems such as lake, river, coast and bays. High NO_3-N, NH_4 and PO_4-P concentrations released from the not treated hospital wastewaters cause eutrophicaton in receiving aguatic media.

2. TYPES OF WASTEWATER

2.1. Industrial Wastewater

Industrial wastewaters produce large amounts of gas, liquid and solid wastes. For this reason, industrial facilities must dispose their waste. Preventive technologies to be chosen should be well defined in order to treat the wastewaters effectively, based on the pollutant partameters. Since the type of wastewaters and the pollutant present in the industries are completely different, the treatment procedures to treat the wastewaters will be different. Therefore, each industry should be considered separately in determining the preventive treatment technologies to be selected. The treatment technologies for each wastewater type should be determined by the quantitative and qualitative properties of the wastewater. The pollutants present in each industrial wastewater can be as follows: organic matter, dissolved salts, toxic substances, color and turbidity, suspended solids, temperature, pH, nutrients, oil and grease, radioactive materials, surfactants (detergents), phenol and phenol derivatives, bacteriological contaminants, flavor and odor-forming compounds, pesticides, acids, petroleum and petroleum derivatives and other non-degradable wastes. Therefore, the above mentioned pollution variables are treated by the conventional treatment processes by taking into consideration the suitable treatment technologies. Nowadays, in order to treat some emergency chemicals, new treatment technologies should be taken into consideration since the accumulated organics in the treatment processes bring a lot of risks to the environment and to the people. Therefore, the industrial pollution negatively affects the environmental health and, therefore, the human health. The amount of water used in the industries in Turkey is 80%. This amount is increasing as the industries are developing. The quality and quantity of industrial water discharged into the natural water environment can cause big environmental damages. In order to prevent this, wastwater can be controlled inside the factory without leaving the factory and the treatment plant. Water sources are not enough and the treated wastewaters should be used again. Recovery and recycling of the treated wastewater with the appropriate treatment technologies will decrease the water consumption in treatment plants [26].

2.2. Domestic Wastewater

Domestic wastewater contains suspended substances, colloidal substances and organic and inorganic substances in dissolved form. The density of the wastewater may vary depending on the density of the clean water used prior sending to the receiving media. The concentration of wastewater varies depending on the daily water used by each one person. This means that the amount of wastewater can vary from city to city, from season to season, even from hour to hour.

2.3. Municipal Wastewater

Urban wastewater is the name of a new mixture of water from a city's municipal wastewater and industrial wastewater and/or rainwater. Urban wastewater is treated with the same method such as the domestic wastewater and industrial wastewater.

2.4. Hospital Wastewater

The chemical substances used in hospitals for care activities and medical research are generally found in the wastewaters. Even if the high volume of generated wastewaters by these establishments ensures an important dilution of the pollutants, the discharge of these effluents in the urban sewer network or in the natural environment generates risks for human health, and represents a significant contribution to the general contamination of the environment, and more particularly of the aquatic environments. The most important pollutants present in the hospital wastewaters are pathogenic microorganism, organohalogen compounds, such as the AOX (halogenated organic compounds adsorbable on activated carbon), radioisotopes, detergents and pharmaceuticals [33].

Comparison of domestic, municipal and hospital wastewater characteristics are shown in Table **4**.

As shown in Table **4**, it can be said that the BOD_5, COD and TSS values of the hospital wastewater are 2-3 times higher than the urban wastewater [34].

The variations of concentrations of pharmaceuticals present in the hospital wastewater are given in Table **5**.

According to the data summarized in Table **5**, micropollutants such as PPCPs (Pharmaceuticals

Table 4: Comparison between Domestic, Urban and Hospital Wastewaters [34]

Parameter	Unit	Approximate ranges of domestic and hospital wastewater	Approximate ranges of domestic wastewater	Physicochemical characterization of hospital wastewater	Hospital Wastewater Average Concentration	Urban Wastewater Average Concentration
pH	-	-	-	8.4±0.3	8	7.5
Chloride	mg/L	-	30-100	185±90.4	200	50
TSS	mg/L	60-200	100-350	225±64	160	60
COD	mg/L	150-800	250-1000	638±435	500	170
TOC	mg/L	50-300	80-290	218±78	-	-
BOD_5	mg/L	50-400	110-400	-	200	90
COD/TOC	-	-	-	3.43±0.92	-	-
Redox Potential	Mv	-	-	-	890	100
TKN	mg/L	-	-	-	33	45
TP	mg/L	-	-	-	4	7
Oil and Grease	mg/L	-	-	-	25	75
Total Surfactant	mg/L	-	-	-	45	5
E.Coli	piece/ 100ml	-	-	-	10^4	10^5
Fecal Coliform	piece/ 100ml	-	-	-	10^5	10^7
Total Coliform	piece/ 100ml	-	-	-	10^6	10^8

Table 5: Average Concentrations of Important Pharmaceutical Compounds in Hospital [34]

Drug Classes	Average Value of Hospital Wastewaters (µg/L)	Average Value of Urban Wastewaters (µg/L)	Avarage HWW / Avarage UWW
Analgesics	100	11.9	8-15
Antibiotics	11	1.17	5-10
Cytostatics	24	2.97	4-10
β-Blockers	5.9	3.21	1-4
Hormones	0.16	0.10	1-3
ICM (Iodinated Contrast Media)	1008	6.99	70-150
AOX (Halogenated Organic Compounds Adsorbable on Activated Carbon)	1371	150	7-15
Gadolinium	32	0.7	35-55
Platinum	13	0.155	60-90

Personel Care Products) and some heavy metals concentrations present in hospital wastewaters are 2-150 times higher than in urban wastewater [34].

3. TYPES AND MANAGEMENT OF WASTES IN HOSPITALS

3.1. Domestic Waste

Domestic wastes may be food wastes or packaging wastes. These waste materials do not pose a threat to human health. However, they can be dangerous for the environment. These wastes mainly consist of uncontaminated waste produced in the kitchen, toilet, garden or administrative facilities. According to Medical Wastes Control Regulation, the wastes are collected in an unit and they are transported as follows; the domestic wastes are collected separately from medical, hazardous and packaging departments in the hospitals and they put into black plastic bags [10].

Domestic waste bags are transported by specific vehicles and temporarily stored in a storage facility.

Domestic waste in the hospitals will always be separated from medical wastes. If there is a mixing of domestic or packaging wastes with medical wastes; domestic or packaging wastes become medical waste and should be treated as medical waste. Collected domestic wastes are transported to the disposal points according to the Waste Management Regulation [11]. The waste management autority in the hospital is responsible to prevent the mixing of different type of wastes. This autority is also responsible for the storing and disposing of the collected waste according to the Waste Management Regulation [11].

3.2. Medical Waste

According to Medical Wastes Control Regulation, medical wastes consist of infectious wastes, pathological wastes and cutter-piercing wastes [10]. The most prominent type of waste in a healthcare facility is medical waste. These wastes are generated in such quantities and qualities that are harmfull to the human life. In healthcare, the goal is to reduce the health problems and eliminate the potential risks to human health. However, some hazardous wastes are unavoidably generated in the process. Compared to other sectors, healthcare wastes carry high infection risks. Wherever waste is generated, it has to be handled safely and reliably. Insufficient and inappropriate treatment of the waste materials may cause serious public health problems and also harmfull effect to the environment. Because of this, safe medical waste management is an important part of the environmental protection. By the application of short- or long- term efficient medical waste management programs, multisectoral cooperation and interactions between hospital administrations are required for all employees studying in hospital, in municipality and in licenced companies. In local places, suitable health policies should be with the international administrative approaches. According to the Ministry of Environment and Urban Planning, for better medical waste managements, more national policies and regulations should be taken into consideration. The training programmes should be applied to the employess and the sensitivity of the municipalities should be increased [35]. Medical waste boxes are easily reachable in policlinic rooms and in patient services. Patients or their relatives sometimes throw the domestic waste materials into these boxes due to being un-educated or un-informed. This not only risks the human health, but also increase the amount of medical wastes and the treatment cost of wastes. This issue should be taken into consideration by efficient medical waste management procedures.

The wastes occuring during healthcare can be classified as infectious wastes, pathological wastes, sharp wastes, pharmaceutical wastes, genotoxic wastes, chemical wastes containing high amount of heavy metals, pressurized containers and radioactive wastes. 4th article of Medical Wastes Control Regulation classifies the medical wastes as infectious, pathological wastes and sharps containing wastes in the hospital units (Medical Wastes Control Regulation, 2017). World Health Organization data shows that medical waste production in countries change according to development level, to income level and to the scale and types of the medical institutes. Medical wastes are rapidly increasing in quantity as the world is developed [36]. In developed countries, 1.1-1.2 kg of medical waste is generated per every patient bed in the hospitals. The weigths of these wastes were around 0.4 and 0.5 kg and is classified as hazardous waste. Annual production of medical wastes were 465000 tons in USA, 150000 tons in Italy, 200000 tons in England and 21000 tons in Australia [36]. Such high quantities of waste materials require trained employees carrying out effectively the collection, the storage and the transportation of these wastes [36].

Medical waste is to be handled separately from the other wastes and they are collected in red plastic bags. Plastic yellow cutter-piercing box is used for cutter-piercing wastes and needles. Medical waste bags are collected by the specific vehicles and temporarily stored in the storage facilities of the hospitals. Collected medical wastes are transported and disposed according to Waste Management Regulation [11]. Medical wastes are delivered to the licensed companies for disposal as D9. D9 is the physicochemical treatment of a final compound or mixtures of compounds discarded by any of the opertions numbered D1 to D12, e.g. evaporation, drying and calcination [35].

3.3. Hazardous Waste

Hazardous wastes are carcinogenic, caustic, flammable, explosive and irritating-harmful wastes, which may be dangerous to humans and to the environment. Hazardous wastes can also harmful to the other living species. Hazardous wastes from hospitals can be explained under five sub-headings such as genotoxic wastes, pharmaceutical wastes,

wastes containing heavy metal, chemical wastes and pressurized containers containing wastes [35].

Pharmaceutical wastes are drugs, contaminated pharmaceutical products, vaccines and serums which are expired, un-used or should not be required to be kept for longer time. These have to be disposed by appropriate methods. This category also includes boxes or bottles used in the preparation of pharmaceuticals, gloves, masks, connection tubes and drug vials [36, 37], Genotoxic wastes are the wastes containing mutant, carcinogenic or some human or animal cells, cytotoxic (antineoplastic) products used in the treatment of cancer, and radioactive material on the cell DNA [37].

1. Wastes containing heavy metals were mercury, cadmium, ana lead-containing wastes in the units, such as thermometers and blood pressure measuring devices. Furthermore, radiation protective panels used in medical fields such as treatment, diagnosis and experimental research materials are toxic [37].

2. Chemical wastes includes gaseous, solid or liquid wastes of chemical substances used in medical fields such as treatment, diagnosis or experimental research units. They are harmful to human and to the environmental health [37].

3. Pressurized containers containing some units, cylinders, cartridges and cans containing gases used in medical fields, such as treatment, diagnostic or experimental research components are toxic [37].

Hazardous wastes are collected separately from other wastes and stored in yellow plastic bags and in blue containers. Yellow plastic bags are used for solid hazardous wastes and blue containers are used for liquid hazardous wastes. Hazardous waste bags are transported by specific vehicles temporarily and stored in a storage facility in the hospital. Collected hazardous wastes are transported and disposed or recycled according to Waste Management Regulation [11].

3.4. Radioactive Waste

Radioactive wastes are solid, liquid or gas materials that are contaminated by radionuclides. These are generated from the *in-vitro* analysis of body tissues or liquids, from the *in-vivo* organ screening and the from the tumor localization. Various studies and therapeutic applications are examples of radioactive wastes. Radionuclides that are used in medical applications are stored closely or openly. Openly stored sources are used directly and they do not have a capsule containing them. Closely stored sources are contained in a device or apparatus inside and they are protected by unbreakable/water-proof containers. When radioactive wastes were produced by an application in the hospital, these waste were received by specific experts working in Turkey Atomic Energy Authority [38].

3.5. Wastewater

The wastewater of the hospital is discharged to the municipal sewage system without any treatment. As described previously, there are very high differences in some parameters between hospital wastewater and domestic wastewater; however, there is no specific discharge standard for the hospital wastewater in Turkish Environmental Legislation. According to Water Pollution Control Regulation, hospital wastewaters are accepted as domestic wastewater [39]. However, in the new application, it is desirable to install a pre-treatment system before discharging the hospital wastewater into the sewage system. These discharge standards for hospitals should be updated by the authorities. The characterization of hospital wastewater will be examined and the hospital wastewater discharges should be subjected with a special legislation.

4. COLLECTING AND STORING OF HOSPITAL WASTES

In addition to the infectious agents and viruses in the contents of medical wastes, they must be treated separately from other wastes. Medical waste is more likely to cause infection and injury than the other types of waste. So, there has been an increase in the hazardous properties of the medical wastes. Since there is a potential risk to human health in the collection, transportation, storage and final disposal of these wastes, there is a problem in the management methods and in the cost for health organizations. Appropriate waste management is provided by the reduction of the desired amount of hazardous wastes. However, the majority of countries today prefer the most economical methods.

Table **6** shows the color codes utilised in the hospitals depending on the collected waste types according to Zero Waste Regulation numbered 30829 dated 12.07.2019 [40].

Table 6: Application of Color Codes in Hospitals According to the Type of Wastes Collected [40]

Color of Bag	Waste Type
Black	Not infectious domestic waste
Brown	Not infectious garden waste
Red	Infectious and pathological waste
Orange	Radioactive waste
Yellow	Hazardous waste
Blue	Packaging waste

According to the Zero Waste Regulation, the colours of bags are determined if the paper, the glass, the metal and the plastic wastes are deposited together [40]. Blue is used for these wastes and dark gray is used for other wastes. If separate deposition is made according to the material types, blue is used for paper waste, yellow for plastic waste, green for glass waste, and light gray for metal waste. In the places where biodegradable wastes are densely formed, tea stoves, cafeterias, food preparation or food service and similar places, brown color is used if these wastes are collected separately. Accumulation equipment to be used for collection of waste drugs; made of stainless metal or high-density plastic material, with a lid, a lock and without sharp edges since these edges may cause damage to collected bags during loading. They should be easy to load, formed in a way that will not be taken back after the waste is thrown and “Waste Drug” located. The relevant legislation shall be guided in the collection of other types of wastes other than those wastes not specified in the Zero Waste Regulation regulation [40].

In the hospital, black bags are used for collecting the domestic waste, blue bags are used for collecting the recyclable packaging waste while the red bags are used for collecting the medical wastes. Yellow boxes are used for collecting the sharp waste, yellow bags are used for collecting the solid hazardous waste and blue containers are used to collect the liquid hazardous waste.

In the collection of medical wastes; the tear, puncture, explosion and transport resistant mediums was sealed with polyethylene raw materials with double layer thickness of 100 microns, and at least 10 kilograms lifting capacity materials were put into the boxes with black colour and the boxes were labelled on both sides. The bags should contain an “International Biohazard” emblem namely “WARNING! MEDICAL WASTE” in red plastic bags. The bags were filled to a maximum of ¾, their mouths were tightly connected, and when necessary, each bag was put into another bag with the same characteristics and it was sealed. These bags cannot be recovered and reused in any way. The contents of the medical waste bags can not be compacted, not be removed with the other medical waste bags, and should be transferred to another container [10].

4.1. Authorities Responsible in Hospital Management

For waste management in the hospitals, the institutions have major roles. These institutions and their roles are stated below for a safe medical waste management;

1. Ministry of Environment: It detects the programs and policies related to the management of the medical waste in accordance with the environment. It carries out periodic inspections and control all activities covering the management of medical waste that should to be disposed. It provides the national and international coordination in the implementation of the latest systems and technologies related to the environmental management of medical wastes. It gives pre-licenses and licenses to the waste disposal and sterilisation facilities.

2. Ministry of Health: It takes the necessary measures to prevent the medical waste threatening the human and the environmental health. It ensures of the health institutions to implement the rules of the regulations in the collection, accumulation, transportation, and disposal of the medical waste separately from other wastes at their source and it implements the necessary sanctions.

3. The local authorities: They conduct periodic inspections of all activities covering the management of medical waste from the formation to the disposal. They provide information to health institutions and municipalities to evaluate the information about the amount of wastes collected and disposed within the provincial borders and send it to the the Ministry of Environment and Urbanism in the form of a report at the end of the year [10].

4. Municipalities: They prepare and applies the medical waste management plan. They transport

the medical waste. They dispose the medical waste. They store and burns the medical wastes [35].

5. The head doctor: She/He directs the necessary studies to reduce the formation and quantity of medical waste at their sources. She/He carries out the inspection of the application of the regulation on the collection, accumulation of medical wastes and prevents the mixture of hazardous and domestic wastes and applies the necessary sanctions.

6. Medical waste manufacturers: They establish the system to minimize the wastes production in the source. They prepare and implement medical waste management plan. They ensure separate collection of waste at source, transport of waste in the unit, and provide the temporary storage of waste by financing the disposal cost [35].

5. CHARACTERISATION OF THE WASTES IN THE INVESTIGATED HOSPITAL IN IZMIR

The hospital wastes can be ranged from completely harmless to highly hazardous wastes. Therefore, a characterization and a classification are essential. First classification is about whether the waste is solid or liquid.

5.1. Solid Waste Groups

These types of wastes have been stated in the hospital by an interier document prepared every year by the hospital authorities according to the requirement of the Ministry of Environment and Urbanism. There are ten different solid waste sources. The sources of these solid wastes are shortly explained in Table **7**.

5.2. Administrative Offices

These wastes were not carried out directly from healthcare-related processes in the studied hospital. They were mostly the same as any other office. The sources of these solid wastes are the administrative offices and they were coming from the photocopy, fax and printing activities, from the utilisation of the electronics and batteries, and from the utilisation of the lamps during illumination of the hospital. The other wastes generated by the administrative offices in the studied hospital were the cartridges, the toners, the fluorescent lamps and the solid wastes from packaging and papers. Among those solid waste, packagings and papers are classified in the domestic waste category. The cartridges, the toners and their containers, the batteries and the fluorescent lamps produced from the administrative offices are hazardous and should be disposed with special treatment processes.

5.3. Clinics

In the studied hospitals, the wastes originated from the clinics were the same solids produced from the offices such as photocopy, fax, printing products and some solid wastes coming the utilization of some electronic apparatus and from the batteries, and from the lamps utilised in the lighting of the rooms. Furthermore, some disinfectants and drugs were present in the clinics. Therefore, hazardous solid materials generated in the clinics (cartridges, toner, batteries, fluorescent lamps, and packaging material) were disposed together with the hazardous substances.

5.4. Dentistry

In the studied hospital; in the dentistry section, dental practices are carried out. Amalgam filling wastes is stated as hazardous waste.

5.5. Radiology

In the studied hospital, radiology is the area which may contain radioactive waste materials. Some solid wastes originated from the X-Ray viewing procedure. The solid waste types produced in the administrative offices are shown in the radiology sections. The wastes originating from the photocopy, fax, printing activities, from the utilisation of some electronic devices, from the batteries and from the lamps utilized during lighting. Furthermore, the cartridges, the toners and the x-ray films are stated as waste materials.

5.6. Laboratories

In the laboratories of the studied hospital, some solid wastes were generated from some of the medical devices used. Furthermore, the wastes coming from the photocopy, fax, and printing devices, from the usage of electronics and batteries and of the lighting were solid wastes produced from the laboratories. Some medical devices in the hospital laboratories generated waste in the liquid form.

5.7. Pharmacy

In the studied hospital, the solid wastes produced from the pharmacy were waste drugs, expired drugs

and drug packaging and medicament materials. Cartridges, toners, batteries coming from the administrative affairs, fluorescent lamps, wastes of photocopies, faxes, printing, of electronics and of batteries and of lighting are the other solid wastes in the pharmacy of the hospital. These solid wastes were not hazardous, unless they have been contaminated with some solid and liquid drugs.

5.8. Technical Workshop

In the studied hospital, the technical sections provides the maintenance of all kinds of devices, as well as in medical devices. The solid wastes originated from the photocopy, fax and printing facilities, from the utilisation of the electronics and from the batteries. Furthermore, the lamps from the lighting devices were some solid wastes. The solid wastes generated by the technical sections also included the excess device parts, the cables, the paint boxes, the cartridges, the toners, the batteries, and the fluorescent lamps. Some of the machine parts can also be considered as solid wastes and these can be classified as hazardous solid wastes. Furthermore, the wastes originating from the photocopy, fax, printing materials, electronics and batteries and lamps were some technical workshop wastes.

5.9. Cafeteria

In the studied hospital the cafeteria provides meals for the hospital. These meals can be eaten by the staffs or by the patients. These wastes had the domestic and packaging waste properties. The packages generated from the raw food materials were solid wastes. These wastes were not hazardous.

5.10. Pathology

In the studied hospital, the wastes produced from the pathology section exhibited similarities with the solid wastes produced from the laboratories section. The solid wastes came from the utilisation of medical devices and from the analyses erformed in the laboratory. The origin of solid wastes is coming from the photocopy, the fax, the printing device, the utilisation of the electronics from the batteries and from the lighting. Furthermore, most of the hazardous chemicals generated in the pathology section and in the laboratory were liquid.

5.11. Operating Room

In the studied hospital, there were some special rooms for surgical operations. From these rooms, the solid waste sources were electronics, batteries and lighting devices, fluorescent lamps, batteries, hepa filters and contaminated packages. Domestic and potentially hazardous materials were categorized. As aforementioned, a lot of cartridges, toners, batteries and fluorescent lamps occurred in most units. Therefore, some waste materials coming from the certain units were labelled specifically with dark color.

Tables **8** and **9** illustrated the total and hazardous wastes and their subgroups produced on years 2012 and 2018. It can be seen that the majority of the wastes

Table 7: Wastes Generated in the each Unit in the Investigated Hospital

Unit	Domestic Solid Waste	Hazardous Solid Waste
Administrative Offices	Packaging, paper waste	Cartridges, toner, batteries fluorescent lamps
Clinics	Drug packages	Cartridges, toner, batteries fluorescent lamps, packages of hazardous materials or contaminated packages, pharmaceutical waste
Dentistry		Amalgam Waste
Radiology		Cartridges, toner, batteries fluorescent lamps, X-Ray films
Laboratories		Cartridges, toner, batteries fluorescent lamps,
Pharmacy	Uncontaminated drug packaging	Cartridges, toner, batteries fluorescent lamps, expired drugs
Technical Workshop	Paint packages	Cartridges, toner, batteries fluorescent lamps, some excess machine parts
Cafeteria	Packaging	
Pathology		Cartridges, toner, batteries fluorescent lamps, hazardous chemicals
Operation Room		Cartridges, toner, batteries fluorescent lamps, contaminated packaging, hepa filters

Table 8: Annual Production of Waste Types (Year 2012)

Hazardous Waste Types with Specific Codes	2012 Production (kg)	Percentage Production (mass)
Toners with Hazardous Content (08 03 17*)	168	1.14%
Fluorescent Lamps/Other Mercury Content (20 01 21*)	369	2.51%
Hazardous Chemicals (18 01 06*)	9189	62.44%
Cytotoxic/Cytostatic Drugs (18 01 08*)	4651	31.60%
Amalgam Waste (18 01 10*)	0.250	0%
Water Based Offset Plate Developer Solution (09 01 01*)	280	1.9%
Batteries (16 06 01*)	60	0.41%
Total	14717	100%

Table 9: Annual Production of Waste Types (Year 2018)

Hazardous Waste Types with Specific Codes	2018 Production (kg)	Percentage Production (mass)
Toners (08 03 17*)	408.12	2.01%
Contaminated Packaging (15 01 10*)	1000	4.91%
Discarded Electronics (16 02 13*)	3140	1.54%
Contaminated filters, rags, clothing (15 02 02*)	69	0.34%
Hazardous chemicals (18 01 06*)	9997.18	49.13%
Cytostatic/Cytotoxic Drugs (18 01 08*)	4940	24.28%
Mercury Containing Waste (20 01 21*)	209.68	1.03%
Paraffin (12 01 12*)	582.46	2.86%
Total	20346.44	100%

originated from the hazardous chemicals and from the cytostatic and cytotoxic drugs.

6. LIQUID WASTE GROUPS

In the studied hospital; it has been observed that, the majority of hospital wastes are hazardous and are in liquid form. The liquid wastes originated from the clinics, the radiology sections, laboratories, pharmacy and cafeteria, pathology rooms and from the operating rooms. The liquid wastes were hazardous. All the units emitting liquid wastes in the studied hospital are summarized below as follows.

6.1. Clinics

In the studied hospital, liquid drugs were generated from the clinics, which are disposed off for various reasons. Some cytotoxic drugs and pharmaceutical wastes are liquid hazardous waste materials generated in the clinics.

6.2. Radiology

In the studied hospital, from the radiology sections, some liquid contrast media and iodinated X-Ray Contrast Media (ICM) were produced. The ICM materials are micropollutants such as diatrizoate, ioxaglate, iopromide, iohexol, iopamidol and metrizoate.

6.3. Laboratories

In the studied hospital, the medical devices used in the laboratories generated wastewater. Sometimes, some wastewaters contained hazardous chemicals. The hazardous chemicals also generated from the medical devices and from the expired reactants. Depending on laboratory type, the medical wastes were some cultures, some stock bacterial media, some infected body fluids, some serological chemicals, blood and some contaminated materials.

6.4. Pharmacy

In the studied hospital, the pharmacy distributed liquid drugs in the hospital to the patients. Some of these drugs were expired and they could not be used. As shown in Table 4.4, the origin of the liquid wastes is expired drugs and vaccines in the pharmacy.

6.5. Cafeteria

In the studied hospital, cafeteria was the unit producing food. Waste oil was the liquid waste produced from the cafeteria.

Table 10: Liquid Waste Types for Hospital Units

Unit	Hazardous Liquid Waste
Clinics	Cytotoxic drugs, cytostatic drugs, pharmaceutical waste
Radiology	Radiology wastewater (Bathing liquids containing silver salts)
Laboratories	Medical device wastewaters (such as tissue tracking device waste), cultures and stocks, infectious body fluids, serological wastes, blood and related products, contaminated liquids by these
Pharmacy	Expired drugs (liquid drugs and vaccines)
Pathology	Chemical Waste (xylol, formaldehyde, methyl alcohol, tissue tracking device waste, paraffin and stain wastes), bodily fluids
Operating Room	Mercury

6.6. Pathology

In the studied hospital, pathology was similar to the laboratories section as they use medical devices and they do analyses. There are various chemical wastes that come from the pathology lab. In the pathology lab. the hazardous chemicals were xylol, formaldehyde, methyl alcohol, tissue tracking device wastes, paraffin and stain wastes such as gram, giemza and malachite green. The medical wastes generated anatomic waste tissues, organs and body parts and various bodily fluids resulting from operations.

6.7. Operating Room

In the studied hospital, some mercury products were produced as liquid waste material in the operating room, due to the utilisation of some special lamps. The majority of all the liquid wastes mentioned above are hazardous and can be classified in seven subgroups. Table **10** exhibited these groups and relevant samples.

7. WASTE MANAGEMENT PROCEDURES FOR THE WASTES OF SELECTED HOSPITAL

7.1. Solid Waste Management Procedures for Selected Hospital

Solid wastes coming from the hospital studied were hazardous waste, medical waste, domestic waste, paper-cardboard waste, plastic waste, metal waste, glass waste, waste battery, organic waste, composite waste, electronic waste, and wood waste. All these wastes should be collected and transported according to procedure prescribed by Waste Management Regulation [11] throughout the hospital and should be transferred to the temporary storage area. Finally, they should be transported by a licenced company for sterilization, recycle and disposal. The management of the hospital wastes should be as follows;

To make some arrangements for waste management throughout the hospital such as to provide trainings for the all hospital staffs, to ensure the correct separation of the wastes and to check all the storage areas and the waste boxes with specific colors regularly,

The hazardous and the medical wastes should be reduced and treated separately, in their sources. These wastes should not be mixed with non-hazardous domestic wastes since the ratio of the hazardous wastes will be increased. On the other hand, the hospital administrations should pay for disposal of hazardous and medical wastes while the domestic wastes are not treated by paying money. These wastes should be collected by the municipality according to the Waste Management Regulation, so the separation of wastes at source is the most important waste management step according to Waste Management Regulation [11].

Training programs should be supplied to the employees relevant to waste management and waste collection in the hospital. Some relevant employees should be sent to the all environmental trainings of Environment and Urbanism and Health Ministry. Finally, the management work should be carried out with the expert emplooyes and stuff who have received all necessary trainings by completing the relevant certificate programs.

Appropriate waste management methods should be choosen according to physical structure of the hospital such as the number of employees and beds, financial and operational capabilities of the hospital. Otherwise wrong management techniques and excess treatment facilities affect negatively the economic situation of the hospital.

A plan should be made about waste collection and storage processing and an application sched ule

should be prepared according to Waste Management Regulation [11].

Adequate tools and equipments and sufficient financial resources for payments to licensed disposal companies should be planned for the implementation of all these waste management activities. The economic resources of hospital should be used effectively for administrative and financial affairs. The reusable products should be sterilized instead of disposing accoding to Zero Waste Regulation, (2019) (Zero Waste Regulation, 2019). Incineration and burning methods for solid wastes were not applied in the studied hospital. Disposal on-site is not recommended due to high operating costs, environmental factors, difficulties in the operational activities, and due to the absence of trained and equipped employees. Furthermore, for this application, special permits and licenses should be taken into consideraton. On the other hand, the Medical Waste Control Regulation recommended that "Health institutions cannot establish and operate individual medical waste treatment plants". Therefore, the wastes should be stored by categorising the solid wastes by appropiate waste management techniques according to the Waste Management Regulation [40].

Solid waste quantities for the year 2018 collected from the examined hospital were recorded and it is presented in Table **11**.

Table 11: Waste Production in the Studied Hospital for Year 2018

Waste Types of Investigated Hospital	2018 Production (kg)
Domestic Waste	unknown
Packaging Waste	12000
Waste Battery	10
Hazardous Waste	20346.44
Medical Waste	582706
Total	615062.44

Some solid waste management proceses were suggested for the investigated hospital. These are:

In the management of the domestic wastes, the solid wastes should be collected in black plastic bags and they should be labeled in the relevant units. However, in the studied hospital, these wastes were transported to the domestic waste depots without weigthing. By using some specialized trucks, the domestic wastes should be weigthed and transported to domestic waste depots everyday. According to the Waste Management Regulation, the domestic wastes should be collected by the municipality facilities [11]. This is the best way to dispose the domestic wastes produced from the hospital. Furthermore, the domestic wastes should be labeled. In this way, the waste amount and the waste mixture will be recorded. This will allow to dentify the wastes and the origin of the responsible unit. Finally, the quantities or each waste type will be determined. Then, the waste type and the waste amounts should be log in to the online system entries of the Ministry of Environment and Urbanization. The management of the domestic wastes in the investigated hospital is summarized in Figure **1**.

In the management of packaging wastes; the packaging wastes should be collected in blue plastic bags. Then, they should be stored in a packaging depot. Packaging wastes in the hospital are nonhazardous and they are recyclable. Main types of nonhazardous hospital wastes are paper, cardboard, plastic, mixed packaging and glass packagings. Nonhazardous hospital waste materials should be gathered in blue plastic bags and should be stored. According to the Packaging Wastes Control Regulation, the packaging wastes should be collected by licensed firms such as MENSAN, which has an agreement with municipality administration [41]. There is no fee for this job, too. The bags should be weighted and labeled. The labels should contain the source of the waste, the date and the weights of the packacing wastes. Labeling of the bags provides to identify the waste types for a possible mix-up of packacing wastes with the hazardous waste. The packacing wastes should be managed according the steps mentioned in Figure **2**.

Waste batteries in the studied hospital are collected in special boxes, which are supplied from MBMIA (Mobile Battery Manufacturers and Importers Association). Then MIBMIA takes back the waste batteries according to Waste Batteries and Accumulators Control Regulation [42]. Ministry of Environment and Urbanism has given the responsibility for the collection of waste batteries to MBMIA. No money is paid for the delivery of the waste batteries to MBMIA. In the studied hospital, the waste battery management was performed according to the regulations given above. The collection of the wasted batteries were performed according to the procedure given in Figure **3**.

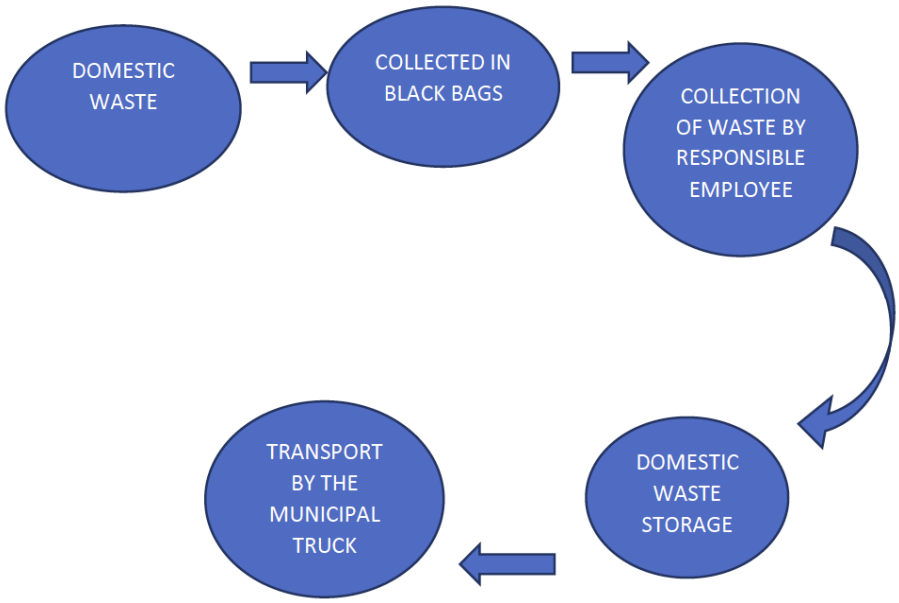

Figure 1: Management of the domestic wastes.

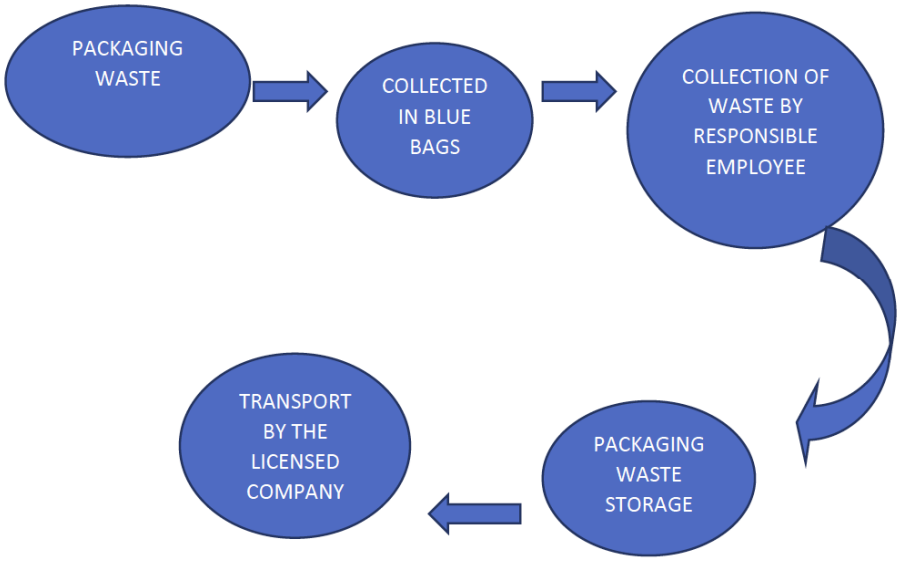

Figure 2: Management of the packaging wastes.

The hazardous wastes in the studied hospital were collected in yellow bags and blue containers then they are stored in a hazardous waste storage depots according to the steps given in Figure **4**. These hazardous wastes are collected and disposed by licensed firm. Hospital pays fee for disposal process.

Medical wastes in the studied hospital are to be handled separately from the other wastes and should be placed into the red plastic bags as shown in Figure **5**. Plastic yellow cutter-piercing box is used to collect the sharps and the needles. The medical wastes are delivered by a licensed company named MİROĞLU for disposal by D9 disposal method. D9 is the physico-chemical treatment resulting in a final compound or mixtures which are discarded by any of the operations numbered D1 to D12, e.g. evaporation, drying, calcination. The studied hospital paid the fee for this disposal process. The management of the medical wastes were performed according to the procedure given in Figure **5**.

Hospitals are increasingly using radioactive isotopes for diagnostic and therapeutic applications. The main radioisotopes used in hospitals are technetium-99m (Tc-99m), Iodine-131(I-131), Iodine-125 (I-125), Iodine-123(I-123), Flourine-18(F-18), Tritium (H-3) and Carbon-14(C-14) [43]. The bulk of the

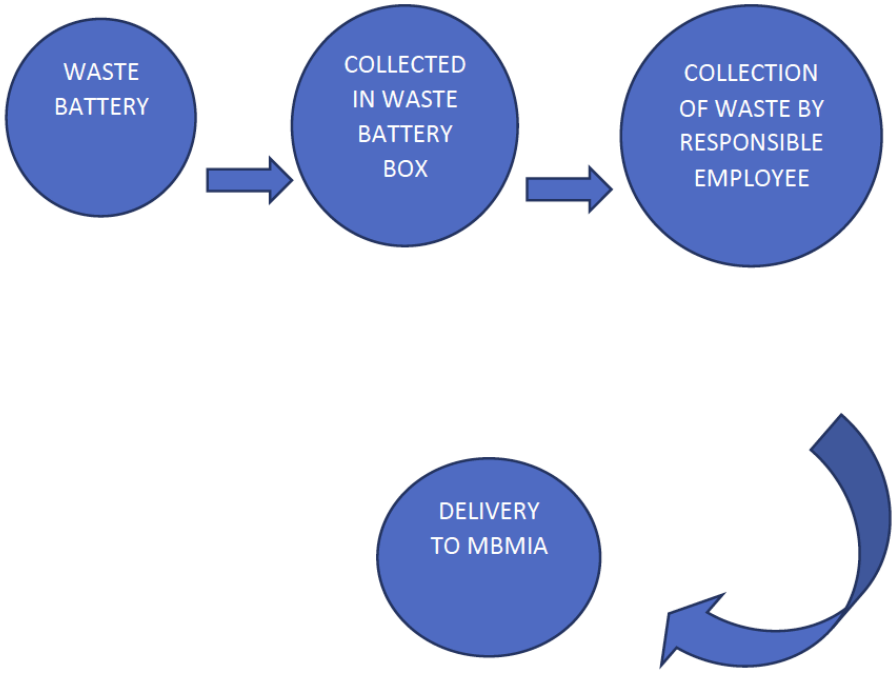

Figure 3: Management of the waste battery.

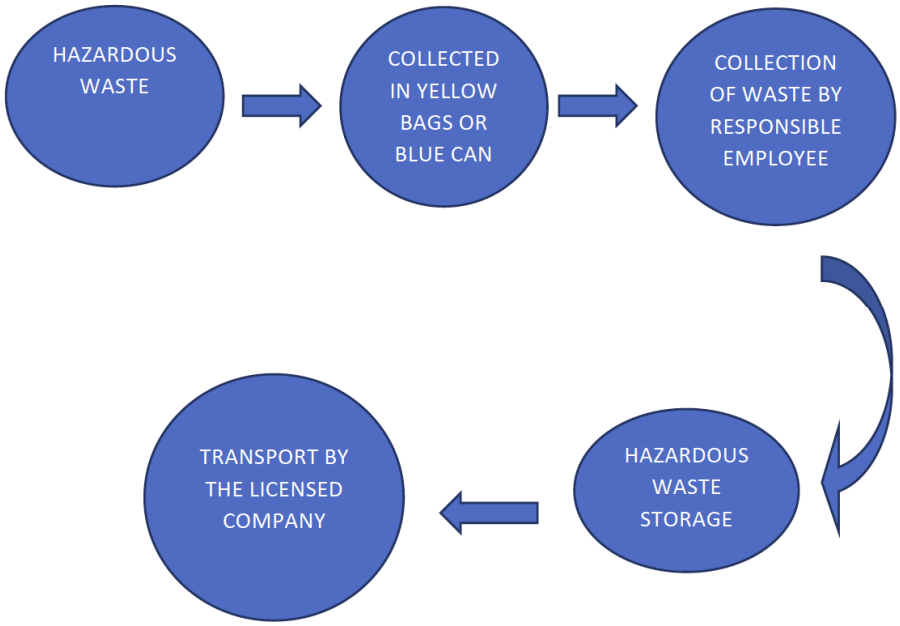

Figure 4: Management of the hazardous wastes.

hospital radioactive waste is generated in the department of Nuclear Medicine. Most of the radioactive waste is liquid, with lesser amount of solid and minimal gaseous. The solid waste containing traces of radioactivity is in the form of syringes, needles, cotton swabs, vials, contaminated gloves and absorbent materials. Clothing and utensils of patients that are administered with high doses of radioisotopes like I-131 should be labelled as solid radioactive waste material. Safe disposal of unused radioactive material and objects contaminated with it is a vital component of the overall strategy of hospital waste management [43]. Regular personal monitoring of the radiation workers in the hospitals and quality control of the radiation instruments is mandatory to asses the quality of existing radiation safety standards [38]. Every hospital should have a designated Radiation Safety Officer (RSO) who oversees all aspects of radiation safety including radioactive waste management. The RSO co-ordinates to measure the accordance with the

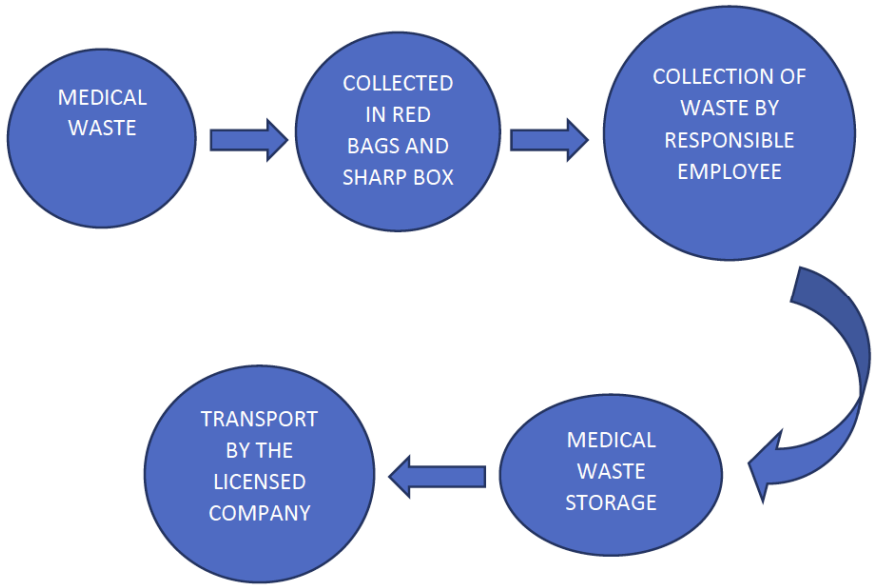

Figure 5: Management of medical wastes.

guidelines prescribed by the International Commission on Radiation Protection and the national regulatory body [38]. In Turkey, the disposal of radioactive wastes should be managed according to the "Guide of wastes occuring from radioactive materials "(2017). The management of the wastes rules are determinded by the International Atomic Energy Agency (IAEA) [44]. The basic principles of radioactive waste management are as follows:

1. Protection of human health: The radioactive wastes shall be managed in a such way to secure an acceptable level of protection for human health.

2. Protection of the environment: The radioactive wastes shall be managed in such a way to provide an acceptable level of protection of the environment.

3. Protection beyond national borders: The radio-active wastes shall be managed in such a way to prevent the possible effects on human health and to the environment beyond national borders.

4. Protection of future generations:The radioactive wastes shall be managed in such a way to predict the impacts on the health of future generations. The impact will not be greater than relevant levels of impact, which are acceptable today.

5. Burning on future generations: Radioactive waste shall be managed in a such way to not impose burdens on the future generations.

6. National legal framework: The radioactive wastes shall be managed within an appropriate national legal framework including clear allocation of responsibilities and provision for independent regulatory functions.

7. Control of radioactive waste generation: Generation of radioactive waste shall be kept to a minimum in the applications.

8. Radioactive waste generation and management interdependencies: Interdependencies among all steps in the radioactive waste generation and management shall be appropriately taken into account.

9. The safety of facilities for radioactive waste management shall be appropriately assured during their lifetime

10. The disposal of radioactive waste begins with the decision to use nuclear tests on the patient or not. If it is decided to utilize the cost-effective tests, clinicians should prefer to use the lowest dose of radiation possible. Mixing of radioactive waste with other waste prevented. Wastes are classified according to their physical (solid, gas or liquid), chemical, biological forms and radioisotopes. Each form of radioactive waste shall be disposed by the appropriate method. Each stage is properly recorded by the National Atomic Agency. Hospital wastes were classified as a source of low activity radioactive wastes

11. Solid waste management is based on the principle of holding waste and reducing the radioactivity. Due to a short half-life of radioactive wastes produced in hospitals, which is less than 65 days, and low amount of radiation wastes were generated, the basic principle of disposal is to keep the wastes and reduce the radioactivity under controlled conditions. In order to control the radiation dose on the surface of the solid waste bags, they should be sent to the medical waste disposal facility. The dose should not exceed 0.1mrem / h level. It is then considered as non-radioactive waste and disposed as medical waste.

12. There is identification, measurement and control in the application of liquid radioactive waste disposal. Radioactive liquid material remaining in the vials and injectors, in the liquid scintillation samples, in the body fluids of the patient should be sent to the laboratories for radioactive diagnosis / treatment. The liquid wastes caused by the washing of radioactive material, and in the liquid wastes containing urine and feces of patients should be connected from a single point at the exit of the hospital. The radiation warning mark sould be placed and radioactivity measurements should be made regularly. The radiation concentration at this point cannot exceed 10 Bq / ml.

13. When the wastes are released in to the environment, their classification and characteristics should be determined. They should be sent to a certified collector, sewage system or atmosphere as medical wastes. These wastes should not contain alpha source and the half-life of the radionuclides should not be less than 100 days. Surface radiation dose rate should be 1 msv / h. It should be placed in red plastic bags that are resistant to transport and have a thickness of 150 microns with an emblem of "international biohazard waste". These wastes should not be loaded to the same vehicle carrying out domestic wastes.

7.2. Liquid Wastes and Wastewaters Management Procedure for Selected Hospital

Currently, the liquid wastes of the studied hospital should be collected separately and they shoud be stored until it is sent to a licenced disposal company (YA-SE) since the liquid wastes of the hospitals are hazardous. However, the studied hospital needs to have a specific storage area for their storing of the waste drugs, waste radiological matters, wastes from laundry, cafeteria services, operating rooms and laboratory activities for their treatments. All these units are the major source of the pollutants emitted to the hospital wastewater. Furthermore, the hospital wastewaters may contain a variety of potentially different hazardous components, including microbiological pathogens, hazardous chemical compounds, disinfectants and pharmaceuticals. According to the Water Pollution Control Regulation [45], hospital wastewaters are similar to the domestic wastewater. Most of the pollutants coming from these units are discharged to municipal sewage system without any treatment process [45]. The municipal treatment process treat only some conventional parameters such as COD, BOD, TN, TP, TSS and SS. The present treatment facility in the municipal wastewater treatment plant can not remove the toxic substances such as drugs, pathogens and pharmaceuticals. As a result, these chemicals are discharged in the receiving bodies (river, lake and marine) since they could not be removed in the conventional treatment plants constructed for the treatment of municipal wastes. Therefore, the hospital wastewaters should be treated on-site with novel treatment processes before being discharged to the sewage system or to the receiving bodies.

Non-hazardous liquid wastes of the studied hospital were directly discharged to the municipal sewerage system without pre-treatment. The hazardous chemical liquid wastes should be collected separately and should be disposed by the licenced firms namely YA-SE according to the Waste Management Regulation [11]. The non-hazardous solid wastes can be disposed as the domestic wastes. Furthermore, there are two main important groups to be handled with care namely infectious and hazardous wastes. Infectious and hazardous wastes in the studied hospital were disinfected, after a proper segregation was performed.

CONCLUSIONS

Waste management in hospitals is an issue that needs to be addressed carefully. A hospital in İzmir was selected to examine the current situation and the management of the wastes. Solid and liquid wastes and wastewaters from hospitals constitutes the main waste sources. The administrative activities to be applied to these wastes have been examined within the scope of the "Zero Waste" Project, which is a current

practice in these days. Each type of waste originating from the hospital and the sources of the wastes should be identified, and the management steps of these wastes should be examined and necessary suggestions should be made. As a result of the examinations, regular training programs should be carried out, the wastes should be separated at their source, appropriate storage space for each waste type should be made. Furthermore, the wastes should be collected in special colored bags and the nonhazardous wastes such as domestic and packaging wastes should not be mixed with hazardous wastes. Economic losses are prevented by decreasing the amount of hazardous and medical wastes since the hospitals paid for disposal. In the studied hospital, since the on-site disposal or recovery applications are not possible according to the current Medical Waste Control Regulation, it was suggested that the hospital should be updated in the solid waste management processes. In the hazardous liquid waste management, the hazardous liquid wastes should be collected in special bins and these bins should be labelled. Then they should be sent to the licensed company for disposal via incineration procedure. Regulations in rules was proposed to treat the wastewater before it was discharged into the sewage system.

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