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Waste Minimization for Small Airlines by Using Safety Management System Concepts

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Abstract: The detrimental effect of the aviation industry comes with its environmental damage, which has inevitably yet significantly increased over the years. Much research is conducted on demoting the environmental damage caused through air pollution, sound pollution, waste pollution, and hydrological pollution. This research aims to focus on developing a system that may reduce and moderate the waste production by the prevention of waste production, which can be done by amplifying a waste management system using scientific methodology and the minimization of waste production through waste type formation reduction. The concepts of safety management due to its inherent qualities of a comprehensive system Top to the bottom management system, a total study of safety in all aspects, has the ability to continuously improve. Furthermore, the organizational commitment from the top management to the bottom is substantial. As in the rest of the world, the aviation industry of Sri Lanka is also mounting at a rapid speed. This research was conducted as a case study of a small aviation industry organization. However, the waste management process of the Sri Lankan aviation organizations has not been given proper consideration to mitigate or prevent the immense waste production. In numerous research studies that have been conducted, the method for managing certain types of waste produced by aviation organizations was discussed. Henceforth, further research developed a waste management system that includes four annexes that can be used for the prevention and minimization of all types of waste produced by the aviation organizations in Sri Lanka.

Keywords: Waste, Safety, Environment, Hazardous Aviation, Management.

Introduction

A. Situation Awareness

1) Globale state: As, the world's demand of aviation services is rapidly growing and the technology of management of resources is in great importance to create cost effective ways to maintain the high quality and safety of air transportation. This paper is orientated towards big markets, particularly to aircraft maintenance service suppliers. These service providers have to act flexibly and efficiently to meet the customer demands. Through the operation of manufacturing and maintaining aircraft for the demand on aviation, potentially large environmental impacts of aviation industry (particularly, airports in terms of air quality, noise, and handling of solid hazardous solid wastes) need to be addressed by developing more sustainable environmental practices followed by its management, and safe disposal. Be it from managing infections due to the ever-growing burden disposed solid waste, exposure to hazardous materials, noise etc. Technical progress and new developments in aviation industry often go hand in hand with the developments in new environmental and

waste recycling technologies for maintaining hygiene and protection of the ambiance both on the ground and in air. As more and more waste related legislation is passed with stringent measures, airports and airlines are struggling to modernize their obsolete waste management systems and recovery procedures. Over the past three years, the progress and space of transformation in international aviation environmental protection, has been unprecedented, driven by key decisions from International Civil Aviation Organization member states, technology progress and societal expectations. Consequently, in this study, we will be comparing the environmental trends in the Sri Lankan aviation industry through the comparison and association of each aviation organization state in Sri Lanka. Thus, Safety Management System concepts are created in a way to emphasize more on "what to do" rather than "how to do it". The reason behind this is to create standards which are set in a way that accommodates a wide variety of types and sizes of organizations. These standards are designed to allow the 3 operators and service providers to integrate the safety management practices into their individual operational models. The absence of harmonized and standardized requirements in the beginning of Safety Management System implementation, the specific needs of the different types of operators/service providers as well as the differences in the existing service provision and business frameworks have set the pattern for the development of sector specific safety management systems. Further research is to comply Safety Management System concepts for an effective waste management through analyzing effectiveness.

Srilankan aviation industry can be dived in to two major components as international and domestic aviation. Srilankan airlines is the only organization in Sri lanka involve in international aviation and the waste is produce through its major operation area of maintenance organization passenger and cargo operations and airport stakeholders like cafeteria and other sources.

In domestic aviation as there are only a very few schedule air transportations. So, the main type of aviation operations is for training and site seeing tours. Due to this reason the only considerable amount waste is generated in maintenance of aircraft.

Critical negative impacts of improper waste management are;

- Open dumping can contaminate water sources
- Contaminate food supply and cause food borne disease
- It can create fire accident
- Slum areas
- It can create nuisance: bad odor, smoke, dust aesthetical problem discomfort: sneezing, coughing

Advantages of optimizing waste management to aviation are;

- Savings in disposal costs
- More economical processes through the recycling and reuse of materials
- Reduction in short-term environmental costs through better process control
- Reduction in potentially large liabilities in the long term
- Reassessment of processes, which may make them more efficient

2) Research questions:

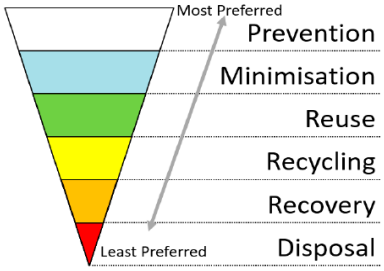
1. What are effects and complications of waste management in the aviation industry of Sri Lanka?

2. Can scientific methodology be use for waste fabrication minimization?

2) Focal points of the Research:

1. Waste management study on the effectiveness of waste management systems in Copenhagen and Kansai International Airports.
2. Waste management study on United Kingdom airports giving the affect of waste on environment
3. Problems of aviation waste management as a globally researched area of emphasis
4. Waste management in Sri Lankan aviation, which seems to be limited to research conducted on solid waste management alone.
5. Scientific methodology which have failed to consider a comprehensive waste management in aviation organization.

3) Objectives of research: The method of waste management in the world



The implementation of waste management systems to achieve the most preferred method of administration.

- Prevention of waste production

The implementation of Waste type formation reduction systems, by taking the amount of waste produce by organization, into consideration.

- Minimization of waste production

Literature Reviews

1) Global waste management: Waste management is the one thing, which just about every government must provide for its resident(Zhu *et al.*, 2008).

At a Glance:

- In solid waste management there is no throwing 'away'.
- The organic fraction of waste, collection vehicles, and waste disposal methods contribute to Green House Gas emissions.
- The last two decades have brought a new challenge for waste management: the growing vagaries of global secondary materials markets(Zhu *et al.*, 2008)

In solid waste management, there is no 'away'. When 'throwing away' waste, system complexities and the integrated nature of materials and pollution are quickly apparent. For example, waste incineration is expensive and poses challenges of air pollution and ash disposal. Incineration requires waste placed outside for collection to be.containerized to stay dry, and much of the waste stream is not combustible. Landfills require land availability, and siting is often opposed by potential neighboring residents. Solving one problem often introduces a new one, and if not well executed, the new problem is often of greater cost and complexity(Zhu *et al.*, 2008).

2) Aviation waste management: Airports are one of the main hubs, which produce waste. Within an airport, there are a number of stakeholders, who are responsible for this production of waste(Baxter, Srisaeng and Wild, 2018).

- Airport offices

- Retail outlets
- Restaurants, Restrooms and flight catering centers
- Air cargo operations
- Maintenance facilities
- Areas and from landscaping Construction and demolition projects undertaken at the airport

In this paper, the central focus is given to aircraft maintenance organizations, for it is one of the two areas that are accountable for the production of much of the waste in the airports.

The waste that are produce by an aircraft maintenance organization like(Mehta, 2015).

- Paper.
- Plastic (in many forms).
- Aluminum cans.
- Grease and oil.
- Electronics Light bulbs.
- Packaging.
- Solvents.
- Toner cartridges.
- Batteries.
- Fuel
- Oils and greases from ground handling equipment.

3) *Safety management is a comprehensive system:*

- Top to bottom management system
- Total study of safety in all aspects

Safety management system of different countries "Aviation safety management systems(Yeun, Bates and Murray, 2014)"

- Adopted to countries with improvement to generic system by Intenational Civil Aviation Organization.(ICAO, 2017)

To link safety management to waste management

Objectives of safety management:

Achieve safety

- For all areas of organization
- Continuous improvement
- Safety hazard identification prevention and mitigation

Objectives of waste management:

- For all areas of organization
- Waste type identification prevention and mitigation
- Continuous improvement

Methodology

1) *Data collection case study of FitsAir through interviews and questionnaires:* With regard to our initial assessment on waste management procedures followed by the Srilankan domestic airlines and the types and amounts of waste produced by the them, we chose the FitsAir aviation for our case-study as it was the main domestic air carrier that engaged in scheduled flights operations.

2) *Data collected by the Srilankan airline annual report and the recourse persons:* The amount of waste collected by the small domestic airlines when compared with large airlines are at a very low amount so in order to incorporate some of the waste that is not produced by small airlines and to compare the amount of waste produce by the small and large airlines.

3) *Data collected by other airlines operating in Ratmalana aerodrome:* In order to get a better idea on the amount of total waste output from the Ratmalana Aerodrome, we collected data linked to other organization.

A. *Case study*

The organization comprised of four Cesna-152 pilot training, where the data about the operation of the aircraft, and waste production by such operation, were collected through interviews and questionnaires conducted at the organization.

B. *Qualitative Data Collection*

As the research was conducted in the form of a qualitative study of the Fits airway, we have focused on the general procedures followed by the domestic airline, when considering the waste disposal and treatment. Higher management involvement in waste treatment of the organization needed to be explicated first, which was done by conducting interviews with the Quality manager and the Manager of engineering.

C. *Interview with the Quality manager*

In the interview with the quality manager of the FitsAir aviation association, the main points conversed, were, the top management's involvement in the organization's waste management, the areas, which needed further upgrading, and whether there were regular interval checks, conducted by the top management or the organization's quality management department, in order to keep the standard of the waste management processes, that was already in place.

Through the interviews, we were able to grasp that the method used for waste management in the organization was not accurately regulated. The amount of involvement by the organization's top management towards waste management was minimum. There was no solid method of collecting and disposing of some of the waste produced by the organization. There was no documentation process in order to clarify the amount of waste produced by the organization and thereby no method, which aids the organization to understand whether the waste produced by the organization has increased and what amount of waste increment, is being introduced, to the environment as harmful untreated waste.

The methods that were followed, were considered by the organization as not adequate to cater for amount of waste being produce by the organization is increasing with the growing of the organization. This will lead to a possible high risk to the environment protection and a need for system that adept with the improvement of the organization was clearly noticed as needed.

The waste materials that were more frequently produced and what waste material that were less produced and what are the more hazards types of waste that was produced by the organization were discussed. What is the area of waste that needed the immediate attention if a process were to be introduced for the organization?

4) *Interview with the manager engineering:* The interview conducted with the fits air manager engineering comprise of similar questions to that were asked by the quality manager of the organization but more concentration was given on waste produce by the maintenance activities of the maintenance operations of servicing, repair and modification.

The waste produced were documented according to type of waste produced and the amount of waste produced and the occurrence of such waste produced in maintenance operations. When considering the whole organization, the types of waste produced by the organization were as such

- Paper
- Plastics
- Aluminum
- Grease and oil
- Electronic light bulbs
- Packaging
- Toner cartridges
- Batteries
- Fuel
- Oil grease from ground handling equipment

When considering the maintenance organization, the amount of waste collected in conducting maintenance activities can be categorized as mainly liquid waste, which includes

- Hazards waste materials
- Fuel
- Oil
- Lubricants
- Hydraulic

The second method used to collect facts from the organization followed by the interview was, once we have understood the top management's commitment towards waste management to get the ground idea of how the waste management operated. In order for this, a questionnaire was prepared by use taking into consideration the waste types taken by interviews and the probability and severity of the waste produced and the waste management process in place already by the organization.

Existing waste management process in the organization

Contemplating the information collected, the waste management of solid waste like paper plastics and batteries and electric bulbs and the airport authority manages other solid waste and regulated by the municipal council in which case the solid waste from making significant damage to the environment is mitigated. So, although the occurrence of these materials was too growing to higher amount the system followed would be adequate to control.

Although the organization process for reducing solid waste is properly managed the liquid waste produced by the organization is not given the proper consideration and it is not regulated by the local body or the airport waste management system. The liquid waste that was collected by the organization was not deposed to the environment in a proper method. Consequently, this liquid waste collected by the organization was a highly possible threat to the environment, and when considering the organization due to an absence of a proper dispose method it was taking the storage space of the organization which is a cost to the organization.

Mainly waste like

- Grease and oil
- Fuel
- Oil
- Lubricants
- Hydraulic

According to the maintenance manual of the Cessna 152, which is the training aircraft used by many of the aviation organization in the Ratmalana aerodrome. There are no maintenance activities, which produce unavoidable waste.

On the daily inspections of the aircraft, it needs to check its fuel quality by removing a sufficient amount of fuel through the drain of the aircraft. In this case, an amount of 0.5 liters of fuel is taken per aircraft and at any instant, the fuel is found not to be at its desired quality the fuel needs to removed completely and re-fueled. This type of situation can add to the regular amount of fuel waste produced by the

organization. In case of such occurrences, the extra amount of degraded fuel more or less, is disposed by the organization in a manner, which is not eco-friendly. When considering the daily amount of unavoidable fuel removed. This amount also adds up to a high amount when taken for a long period of time (year).

At the 100-h inspection of the aircraft, it needs to do a full oil change where the remaining oil from the aircraft is taken out completely. The inspection occurred according to fight hours but at least once per aircraft within two weeks' time.

At each 200-h inspection, the hydraulic system of the aircraft brake system needs to be refiled and bleed out to remove entrapped air from the system.

Before all maintenance, activity aircraft need to be cleaned by using water and detergents

In addition, when considering the amount of waste produced by the organization and the probability of such waste produced oil was a major concern. The organization used piston engine aircraft for its flights, which needs to change it oil completely every two weeks. A deep study was conducted about oil waste in the organization.

The organization comprised of four Cessna-152 pilot training aircraft which used AeroShell W-100 lubrication oil. The oil needs to be completely changed at each 100h service which occurred every two weeks the amount of oil used for an aircraft is 7 quarter (6.624L) and about 6 quarters (5.678L) of oil is removed as used oil per service a very small amount (0.5L) of used oil was kept for the reuse within the organization.

D. Activities conducted

1) *Actions of oil purchasing and oil storing*: The methods of oil ordering were done on the base of stock remaining. A minimum amount of stock in the store was kept at 35 quarters (33.122L) and this amount was re-stocked by 250-255 quarters. The storing of oil was done according to the guidelines given. The release of oil to service was done as 7 quarters. There was no method of calculating the amount of oil used for annum to get the amount needed for the entire year. The main problem being a small organization and the number of flying hours of aircraft being inconsistent.

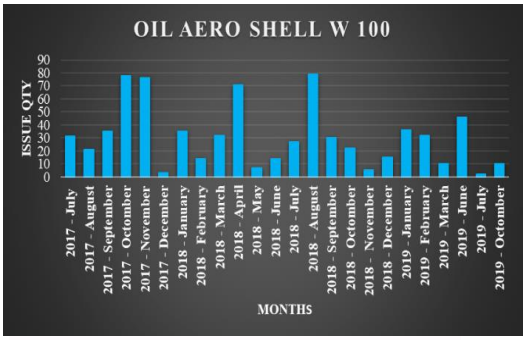


Figure 3-12. Oil usage per month graph.

2) *The amount of oil used per service:*For the 100h service of each aircraft total of 7 quarters were needed and amount of oil removed from the aircraft as used oil was about 6 quarters per each service per aircraft in the below given chart 44 weeks were taken for the calculation for a year

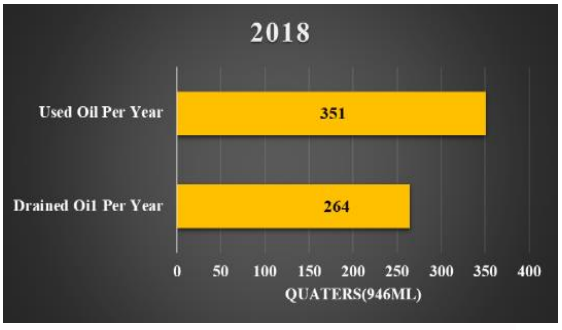


Figure 3-13. Amount of used oil per drained oil in 2018. The storing of used oil

After the removal of used oil, they are collected in containers and transferred to the stores. Then from the stores a very small amount is reused for the organization works where the rest of oil needs to be removed from the organization.

In FitsAir, there are certain consumers of these used oil but the amount of used oil taken from them is rather low when considering the amount of oil that is removed.

- Sales to individuals, sawmills, furniture makers, timber producer.
- Taken by block makers to be used as lubricant in mold equipment.
- Taken by service centers for maintains activities of vehicles.

However, as the amount of removing oil to sales of oil ratio is high, there is a high collection of oil within the organization. That need to be removed as the space occupied by these containers is a negative factor in the organization so the other method that is commonly used is to dump the removed used oil from the aircraft without filtration directly into the environment.

The outcomes of visit

- Identifying the methods used in the organization on purchasing and storing of oil in the organization
- The quantity of oil need and for a servicing of the aircraft in the organization the amount of used oil removed from the aircraft
- The procedures followed on removing the used oil from the organization
- What are the main problems associated with the waste oil management in the organization?

The problems in waste oil management

- The direct environment effect of dumping oil was not regarded as a concern of the organization. The main goal of the organization being to remove it from the organization.
- Recycling of used oil by the organization to reduce the environment effect was not seen as cost affective as the amount of oil removed per service was low and the limited area and the manpower of the organization was also a concern.
- There was no proper procedure to remove the used oil from the organization.

After conducting a deep analysis on the production of oil waste by Fits Aviation we further concluded that there is a significant amount of liquid waste produced by the organization, due to its maintenance activities. Considering organizations which use similar types of aircraft fleet for its flight's operations, we were able to find data within the aerodrome of the Ratmalana airport. As these aircraft need to be maintained in a similar manner the amount of waste produced by each fleet can be considered more comparable to that of FitsAir. These organizations are also operating under the Ratmalana airport the liquid waste problems faced can be identified as identical and the environment affect due to them as such.

E. Objective combination

The main objectives for an effective and efficient waste management system need to be met by the combination the safety management system concepts for developing our waste management system. The interviews conducted with top management of the case study organization clearly proved that there was a lack of top management involvement in managing the waste produced by the organization.

Results

A. Srilankan airlines data analysis

By considering the data, we have looked into the per flight waste generation of the fleet of Sri Lankan Airlines with respect to other domestic air lines in sri lanka. Hence we have collected and anlyzed data from the domestic airlines by inspecting and interviewing organization managements., furthermore, we have analyzed data from maintenance program document. We have found the detailed quantities of the aircraft maintenance waste per 750FC and 6000FC. By taking these amount we have found the waste generations per year 2017, 2018, and 2019.

The hazardous waste fluid materials that are generated through the maintenance process are fuel, engine oil, Auxiliary Power Unit oil and hydraulic fluid. Quantity of waste per for one site emergency have been found from the Maintainance Planing Document (Cedex, 2010). Also have found the waste generation per flying hours 750FC. Therefor due to the total number of aircraft services done at the end of year 2017, 2018 and 2019. We have taken the same path to find the total waste per year for the flight hours 6000FC (C & D checks).

Table 16. Total waste of waste per flying hours 750FC.

Waste Material	**Total Waste 2017 (Liters)**	**Total Waste 2018 (Liters)**	**Total Waste 2019 (Liters)**
Fuel	1440	1560	1620
Engine Oil	168	728	756
APU Oil	192	208	216
Waste Water	912	988	1026

Table 4-1 depicts the types of waste produced and the total amount of waste produce per each type per year in the consecutive years of 2017,2018 and 2019. The waste have been produced 750H servicing of the aircraft. In Srilankan airlines the amount of waste produced in the table 4-1 it can be seen that in each case the amount of waste produced have been increased with each year and the highest amount of waste have been produce in fuel waste collected by the organization and the followed by waste produced by waste water and there after engine oil and last due to Auxiliary Power Unit oil. So, the amount of waste produce as a total in engine oil and fuel has been at a high amount.

The table 4-2, depicts the types of waste produced and the total amount of waste produced per each year in the consecutive years of 2017,2018 and 2019. The waste products are produced of 6000H servicing of the aircraft. In Srilankan airlines the amount of waste produced when considering the types of discussed in the table 4-2 it could be seen that in each case the amount of waste produced has increase with each year and the amount of waste produce is highest in fuel waste collected by the organization and the followed by waste produced by waste water and there after engine oil and then add amount of waste by hydraulic fluids and thereafter at last due to Auxiliary Power Unit oil. So, the amount of waste produce as a total in engine oil and fuel is at a high amount.

Table 4-17. Total waste Srilankan airline at waste per flying hours 6000FC.

Waste Material	Total Waste 2017 (Liters)	Total Waste 2018 (Liters)	Total Waste 2019 (Liters)
Fuel	1440	1560	1620
Engine Oil	168	728	756
APU Oil	192	208	216
Waste Water	912	988	1026
Hydraulic Fluid	348	377	391.5

B. The Domestic small airline data analysis

Going through the domestic aviation organization maintenance program, we had analyzed the same materials, which is can risk the organization's environmental safety. the table 4-3 shows the data gathered about the aircraft operated similar to the operation of case study organization and with the information of aircraft fleet.

Table 4-18. Aircraft fleet of organizations in Ratmalana Aerodrome.

Aviation Organization	Aircraft Type	Number of Aircrafts
Fits Air	CESSNA 152	4
Asian Aviation	CESSNA 152	3
Sakurai Aviation	CESSNA 172	2
Skyline	CESSNA 152	3
		total =12

The table 4-4 shows the types of waste resulted by waste that have been produced by the organization and the amount of waste produced daily and at each 100H check of the aircraft mention in the above table. The information below were calculated according to maintenance activities given in the Maintenance Programme document and with the organization procedure.

Table 4-19. Waste produce at daily and 100H check by fuel, oil, waste water hydraulic fluid.

200H check (mounthly)			Total waste per year			
Liters	Gal	Total waste (liters)	daily check (liters)	100H check (liters)	200H check (liters)	total waste per year
10	2	120	7200	5760	5760	18720
25	5	300	0	14400	14400	28800
5	1	60	0	0	720	720
2	0.4	24	3600	1152	288	5040

Table 4-20. Waste produce at 200H and total waste per year.

Waste Material	Daily Check			100H Check (2 weeks)		
	Liters	Gal	Total waste (liters)	Liters	Gal	Total waste (liters)
Fuel	2	0.4	24	10	2	120
Engine Oil	0	0	0	25	5	300
Hydarlic Fluid	0	0	0	0	0	0
Waste Water	1	0.2	12	2	0.4	24

The table 4-5 shows the types of waste occurring dur to the type of waste been produced by the organization and the amount of waste produced per 200H check and the total amount of waste produced by the organization per year for the aircraft mention in the table 4-5. The table 4-6 data were calculated according to maintenance activities given in the Maintenance Programme document and with the organization procedure

Table 4-21. Waste production comparing of Srilankan airlines with Ratmalana aerodrome aviation organizations

Waste Material	***Sri Lankan Airlines***	***Domestic Aviation Organization***
Fuel	*18720*	*1620*
Engine Oil	*28800*	*756*
Hydraulic Fluid	*720*	*216*
Waste Water	*5040*	*1025*
APU Oil	*216*	

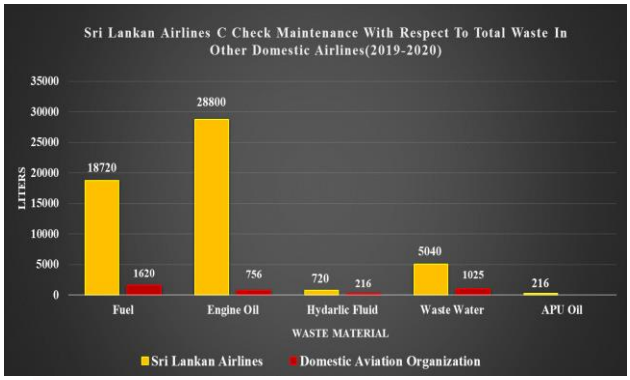


Figure 4-14. Amount of waste produce per year 2019-2020.

The figure 4-3 compares Srilankan Airlines waste generations per the year 2019 with respect to other domestic aviation organizations waste generation. Consequently, through analyzing the graph we could see from total fuel waste 14% of waste fuel has been generated from Srilankan aviation C & D check maintenance. But only 2% of wasted engine oil has been generated with respect to total engine oil waste generated from other domestic aviation organizations. Therefore, domestic aviation industries must highly concern about engine oil waste. Thus 30% of hydraulic fluid waste have been generated from Sri Lankan airlines C & D check maintenance with respect to other organizations. So, it must highly concern on the Sri Lankan aviation. Waste water is not concerned since it is organic waste which is not hazardous. Also, 216L of Auxiliary Power Unit oil waste generated only from Srilankan air lines organization. Through the analysis we could see the total aviation hazardous waste fluids generations by taking the total amount of waste materials of all aviation organizations in the country.

C. Waste Generation Projections for 2025 by Income Region

comparing the projections of 2025 of waste generation of low middle-income countries sri lanka commercial aviation organizations fluid waste generation will be 1.86% of total waste generation of all low middle-income counties.

Wherefore, we can use safety management concepts for effective waste management, considering environmental aspects and per organization standards.

Conclusion

The research provided definitive proof that the waste, which is spawned by the aviation industry, is increasing due to its escalation and with the increase of the waste production. Therefore, organizations are going into waste removal and disposal methods that can harm the environment at a very high rate. We have mentioned how the necessity of a proper system of management to mitigate and prevent the waste production and if the waste production is un avoidable, then use of treatment before disposal to environment is needed. Through the analysis of aviation maintainance organization waste we included waste risk management as a safety management system concept to analys the levels of hazardous waste also as a waste minimization process. Thus through the analysis of risk management for a continouce waste management sytem waste management assurances and waste management promortions are recommended for the implemented waste management system. The amount of waste is always increasing and any system that is put in place need the total commitment from the organization; from the top management to the bottom. Waste management policies and objectives are recommended to the impimented waste management system and as a safety management system concept. With the basis of safety management system concepts, when introduced a waste management system; need to be able to adept with the organization development and a methodology to

continuously improve as stated. The aviation organization small and large has not given the due care to the amount of waste that they are producing and removing into the environment. Although, the amount of waste produced by small airlines are not significant when compared to large airlines, when it comes to hazardous waste such as fuel and oil, they are continuously released to the enviorenment, without any treatment though the damage to the eco system will be high.

Recommendations

A. Waste management policy and objectives

- Purpose of waste management system
- Benefits of waste management system
- Positive waste management culture
- Waste management values
- Priority of waste control
- Waste management policy statement
- Organization structure

B. Waste management risk assessment

- Categorization of risk
- Severity
- Probability
- Risk matrix
- Mitigation process
    - Avoidance
    - Reduction
    - Segregation of exposer

C. Waste management assurance

- Waste management inputs
- Acceptable level of waste disposal
- Waste management performance monitoring and measurement
- Waste disposal hazard reporting system
- Occurrence reporting – Flow chart
- Waste management quality database – WQD

D. Waste management promotions

- Waste management training
- Types of training
    - Initial training
    - Recurrent training
    - Update training
- Documentation of training program
- Presentation of training
- Validation of training
- Training program review
- Training files

Limitations

- Unavailability of waste collection data document
- Data speculated by
    - Inventory records
    - Maintenance planning document
    - Organization annual report
- Organizational waste limitation
- The amount of research related to aviation comprehensive waste management limited
- The current global situation preventing the application of the system to a large aviation organization to measure its effectiveness

Areas for Further Research

- With sufficient accurate data from each organization to continue the waste type reduction process
- Implementation of waste management system for large organization to evaluate effectiveness

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