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Health Issues of Dwellers around the Urban Solid Waste Dumpsites in Sri Lanka: Comparative Analysis of Colombo, Kandy, Kurunegala and Badulla Urban Areas

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ABSTRACT: Improper urban solid waste management will directly and indirectly affect the land, water and air; causing multifarious human health and environmental risks. However, such issues cannot be wiped-off completely, but its volume and risk levels could be minimized and managed at an acceptable point. Accordingly, the prime objective of this is to identify and compare the health issues related to urban solid waste disposal; among the selected study areas according to its geographical variations and provide possible solutions in terms of mitigation and management. Colombo and Kandy municipalities from wet agro-ecological zone and Kurunegala and Badulla municipalities from intermediate agro-ecological zone were incorporated as samples for this study. These four sample study areas were selected considering its different elevation ranges and the prominent urban areas with different geographical features and existence of crucial solid waste related issues; following the mingle of both purposive and stratified sampling methodology. Total 867sample households were selected, following stratified random sampling technique. The structured and semi structured questionnaires were also used to collect primary data from various target groups. The collected primary data were coded and analyzed, using Microsoft Excel and SPSS, ANOVA and ANOVA Scheffe's as appropriate. The study identified 23 types of similar diseases in all selected sample areas; however its volume and the risk level are varied; based on its geographical factors, population density, volume of waste generation/collections, literacy level, income level, public behaviors *etc*. Out of total health issues, the Colombo site accounts for 45.6%, Kandy-21.4%, Badulla-17.6% and Kurunegala-15.4%. Further, this study found that 56.7% of female populations have been victimized with different types of health issues, than the males (43.3%), since they spent more time around the dumpsites as housewives and waste pickers. Similarly, 65.5% of children population, 75% of waste pickers and 70% of waste collectors/vehicle drivers have also been affected by multiple health problems, due to the direct contact with waste dumpsite. This study recommends central point for managing, monitoring and controlling all process of environmental related activities and implementation of integrated solid waste management (ISWM) system, consolidating all related factors of waste management hierarchy into a center point.

Keywords: Agro-ecological zone, environmental risks, geographical variations, health issues and solid waste management

I. INTRODUCTION

Disposal and Management of urban solid waste in Sri Lanka has become a major threat, due to its population density, public behaviors, and high volume of waste generation and lack of land space for allocating a disposal site. The high volume of solid waste generation is accelerated in the urban area, due to the drastic increase of population density, floating population, economic growth, urbanization, industrialization and commercial imports. The solid waste generation in Sri Lanka is 7,000MT/day and each person generates an average of 1-0.4kg of waste per day. The urban arrears responsible for 80% of it and the western province accounts for 60% of total waste collection per day. The local Authorities (LAs) are managed to collect approximately 3,000-3,500 MT/day only (Ministry of Environment, 2012). Approximately 50% solid waste are ended-up with water bodies, cannels, low lying areas, bare lands, around the so-called disposal sites and also scattered in urban centers; which produce multifarious health issues, *viz,* vector borne diseases (dengue, malaria, chicken guinea, rabies and skin rashes) and respiratory diseases (asthma, breathing difficulties and wheezing) (Abeysuriya, 2007). The major causes behind this situation are lack of infrastructure for collection, transportations, improper solid waste management planning, insufficient financial resources, technical expertise, public attitude and open dumping of solid waste disposal without treatment and other similar drawbacks with respective Local Authorities; which will directly cause negative impacts to the land, water and air of its territory

and create multifarious environmental and human health problems to the urban dwellers. In fact, such environmental and health issues cannot be wiped-off completely; nonetheless its volume and risk levels could be minimized and managed at an acceptable point. Considering current situation of urban solid waste disposal and management practices of Sri Lanka, this study tends to find possible solutions to mitigate such solid waste related health issues and to drive a productive management practices in geographical perspective; incorporating four urban areas from different topographical locations for this study.

1. Objectives of the study

Main objective

Identification and comparison of the health issues related to urban solid waste disposal, among the selected study areas, according to its geographical variations and provide possible solutions in terms of mitigation and management.

Sub-objectives

i. To identify and analyze the health issues, causes and its differences in the context of its risk level, volume and diseases types, according to the topographical variations of the study sites.
ii. To investigate and analyze the existing issues related to the solid waste management (SWM) practices, adhered by the respective local authority of the study areas.
iii. To provide possible solution to overcome the health related issues, through integrated urban solid waste management system.

II. REVIEW OF LITERATURES

The relevant literature have been collected from various sources; such as journals, magazines, books, research papers, websites and other relevant source of information. After a careful perusal, the relevant information has been organized into two broad categories, such as description of key terms and other relevant literatures. A few of which are depicted below.

Brown (2006) described that the geography is a study of the earth's landscapes, people, places and environment. It is an understanding of social and physical processes within the context of places and regions; recognizing the great differences and the links between cultures, political systems, economies, landscapes and environments across the world.

Brown (2006) further described that "geographical perspective offers a unique way to understand anything that is distributed across the earth, including the ever changing relationship between humans and the environments". Accordingly, the geographical perspective refers to spatial analysis (uniformity and variances) of any issues in terms of topography, elevations, climate and hydrology.

The word "urban solid waste" was defined by Zhu *et al*. (2008) as "any discarded materials by the public each day in the cities and towns, supervised and controlled by elected local officials or county governments".

The solid waste problem has become one of the most significant environmental issues in urban areas of Sri Lanka. Unscientific management of waste, such as open dumping and open burning are the present disposal methods, especially in developing countries, which create numerous environmental dilemmas; such as pollution of ground and surface water, widespread vector borne and other related diseases, emission of noxious gases and creation of social disparity in terms of people (MoE, 2019).

Christian (2002) expressed, most of the urban solid waste in developing countries is dumped on land in a more or less uncontrolled manner. These dumps make very uneconomical use of the available space with the attendant evil of pacing the path for free access to waste pickers, animals and flies. Moreover, it often produces unpleasant odour, hazardous smoke from slow-burning fires and greenhouse gases.

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of ground and surface water, widespread vector borne and other related diseases, emission of noxious gases and creation of social disparity in terms of people (Ministry of Health, 2011).

As illustrated by Werellagama and Samarakoon (2007), urban solid waste generation showed a different trend and a positive correlation with economic development. Urban areas of Asia generate approximately 2.7 million m^3 of waste per day. The World Bank (2012) has estimated that in the year 2025, volume of solid waste generation in the Asian region will raise to 5.2 million m^3/day. According to the World Bank (2013) report, currently world cities generate about 1.3 billion tonnes of solid waste per year. This volume is expected to increase up to 2.2 billion tonnes/year by 2025. Waste generation rates also will more than double over the next twenty years in lower income countries.

In addition, WHO (2010) declares that recycling too carries health risks, if proper precautions are not taken. Workers handling waste containing chemical and metals may experience toxic exposure. Disposal of health care wastes require special attention, since it can create major health hazards, such as Hepatitis-B and C through wounds, caused by discarded syringes. Rag pickers and others, who are involved in scavenging in the waste dumps for items that can be recycled, may sustain injuries and come into direct contact with these infectious items. It is estimated that, in the year 2010, contaminated injections with contaminated syringes caused 21 million people effected with hepatitis-B virus (HBV) infections (32% of all new infections); 2 million effected with hepatitis-C virus (HCV) infections (40% of all new infections); and at least 260,000 people stimulated with HIV infections (5% of all new infections). In 2012, the results of a WHO assessment conducted in twenty two (22) developing countries showed that the proportion of health-care facilities that do not use proper waste disposal methods ranges from 18-64%.

Management of urban solid waste provides many opportunities for reducing greenhouse gas emission. Source reduction and recycling can reduce emissions at the manufacturing stage, increase forest carbon storage and avoid landfill methane emissions. Combustion of waste allows energy recovery to displace fossil fuel-generated electricity from utilities, thus reducing greenhouse gas emissions from the utility sector and landfill methane emissions (Bandara and Hettiarachchi, 2010).

Above are a few citations, extracted from the more literatures that are reviewed by the Researcher.

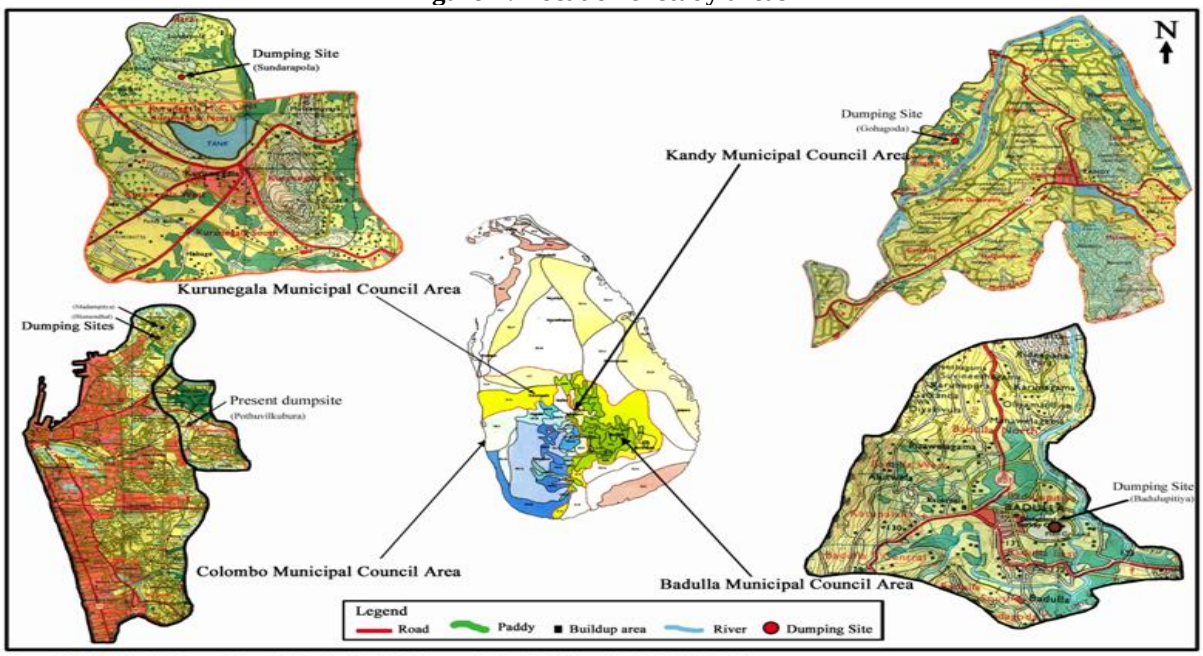
III. METHODOLOGY

Accordingly to the objective, this research has been designed to look at the urban solid waste related issue and management practices in the aspect of geographical dimensions, selecting four urban areas from two major agro-ecological zones (AEZ), *i.e.*, wet and intermediate AEZ, which has uneven geographical factors. Accordingly, Colombo and Kandy urban areas are from wet ecological zone and Kurunegala and Badulla from intermediate ecological zone were identified. Methodology including rational for selecting study areas sampling scheme, data collection and analytical techniques has been developed, based on the initial data gathered from literatures and pilot survey.

a. Study area

The present study area consists of four Municipal Councils (MCs), which are Colombo, Kandy, Kurunegala and Badulla. The selected four locations show different types of physical and socio-economic characteristics, together with dissimilar waste management methods (figure-1). Large volume of solid waste generation and their impact on the environment, health issues, topography, vegetation, hydrology and micro climatic conditions are major reasons for selecting these four study areas. In addition, the existing actual situation of the solid waste related issues, in terms of its volume and risk level was also contributed in the selection process of study areas. The dumping site of Colombo is located at the Blumenthal/Madampitiya (previous sites), which is situated within the Colombo MC area. The current site in Meethotamulla area was shifted, out of the Colombo MC limit from 2017 onwards. The Kandy site is located at Gohagoda, which is situated 3 km from Kandy town and outside the Kandy MC area.

Figure-1: Location of study areas



Source: 1:50000 Colombo (sheet no 66) metric sheet Kandy (No 54); Kurunegala (No 47); Colobmo (No 66); Badulla (No 69)

Solid waste dumping of Kurunegala is located at Sundarapola, which is 2 km from the Kurunegala town and outside the Kurunegala MC area. In addition, Badulla waste dumping site is also located within the Badulla MC area.

b. Rationale for selecting study area

The investigator examined the geographical factors, topographical features, population density, solid waste generation, location of dumping sites of 19 MC areas of the Island, extracting the statistical information from the statistical data base of Municipal Solid Waste (MSW) of Sri Lanka (MoE and CEA, 2012) and unpublished reports and metric sheets (1:50,000) of relevant LAs and telephone interviews with officials. The wet and intermediate AEZs, avoiding dry ecological zone were incorporated for this study; since dry ecological zone has three MC areas (Jaffna, Ampara and Batticaloa) with minimal solid waste related issues, whereas wet and intermediate AEZs has 40% land area and 15 MCs with large amount of solid waste related issues. Two municipal areas, as stated above, from each AEZs have been identified, based on it topographical elevation and representation of different geographical factors, such as terrain, soil, rainfalls *etc*. Accordingly, the Colombo and Kandy MCs represent the low-country wet AEZ (below 300 m from the sea level), whereas Kurunegala and Badulla MC areas represent the mid-country intermediate AEZ (between 300-900 m from the sea level).

c. **Sampling scheme**

A sampling scheme was prepared, considering the population density/distribution, geographical features and volume of solid waste related issues. Accordingly, the percentage of the sample was decided proportionately to the population density of each study area. Finally, 867 households out of 20,739 from the selected study areas were incorporated for the house hold survey. In addition, it was observed that the selected MSW dumping sites for this study are mostly in the midst of the low and middle income people. Further, its topographic features are different and the same uniformity had to be maintained in all selected study areas in

demarcating sample size. Similarly, impacts of solid waste dump site also were equally felt among the people, who lived around the garbage site. Therefore, it was decided to draw distance wise imaginary rings, considering dumping sites as the center point, which is most acceptable and suitable technique for this study and to collect unbiased information from the neighboring residents. Accordingly, each study area was stratified into three rings. The first ring was from 0 to 500 m, the second ring 500 m to1000 m and the third ring 1000-1500 m from the respective dump site. The samples were selected randomly from the each ring. Methodology including sampling scheme, data collection and analytical techniques has been developed, based on the initial data gathered from literature and pilot survey. An area of 7,069m2 around the Colombo dumpsite was incorporated for this study and it was stratified into three rings (0-500m, 501-1000m and 1001-1500m), according to the distance from the site. Further, health issues were analyzed; captivating three major variables (distance, direction and location of the residences), comparing with the waste dumpsite.

Consequently, stratified random sampling technique had been used to collect household information. A convenient sampling technique was used for collecting data from the waste collectors and drivers, public health inspectors, public health midwives, chief medical officers and school principals. through structured and semi-structured questionnaire survey. The participatory appraisal survey (PRA) survey was also conducted with selected focused group. Field observations and discussions with communities, relevant officials and institutions were also completed in the each ring. Relevant secondary data were collected from the officials at the time of interviewing them. Further, several discussions, interviews and telephone discussions were held with the environment related institutions, officials and individuals for the purpose of collecting informal data and to obtain clarifications for shortcomings in answering the questionnaires by the households. Further, secondary data were collected from sources of published and unpublished documents in the form of soft and hard copies, which were used for resolving critical points, whilst collecting and analyzing the formal primary data.

d. Data analysis

Both primary and secondary data were analyzed, focusing on the objective of this study, using Microsoft Excel and SPSS computer packages. The two-way ANOVA is mainly used to compare two variables (e.g., distance/dumping site, direction/dumping site, location/dumping site). Further, standard statistical techniques, such as percentage analyses and correlation analyses were used, wherever applicable. Further, the comparative approach on the health issues of the selected study areas was derived, using ANOVA Scheffe's method. Human health issues have also been analyzed, selecting four study areas from two different AEZs, comprising with different physical features and socio-economic characteristics. Collected data on human health damages, using different data collection techniques have been analyzed, considering location of the dumpsite as a constant factor and distance, direction and location wise health issues as variable factors (distance, direction and location). Then again, variances and relationship between constant and variable factors have been analysed quantitatively.

IV. JUSTIFICATION OF THE STUDY

The system of open dump solid waste in Sri Lanka was operating since the 1970s. However, no waste compaction was undertaken during the placement of waste. The slope formed by the heap of solid waste was very steep with burning matters, which were dumped on top of the heap in the Colombo-Bloemendhal dumping area. An "explosion" had taken place on 24th April, 2008, followed by the eruption of a large mass of solid waste, which engulfed 100 houses, causing deaths of 03 people. Generally, the dumping of solid waste has not been done in a stable manner in all the study areas. Therefore, mountains of waste produce toxic gases; containing methane, odours and vectors and it was an extremely unhealthy environment for human habitation. In brief, open dumps of solid waste gradually degrade public health, the living environment and human behaviour creating social disparity in vicinity of the dump sites.

On the other hand, different geographical backgrounds were observed in selected study areas. Accordingly, it was decided to conduct a comparative investigation of the geographical impacts on solid waste related issues. Accordingly, this study is expected to be very helpful and significant to the policy makers, who design the sustainable solutions to minimize the adverse effects of solid waste disposal, through productive management system.

V. ANALYSIS OF SOLID WASTE RELATED HEALTH ISSUES

Analysis have been carried out by way of percentage analysis, two-way ANOVA and ANOVA Scheffs's test mechanism to drive the results on different viewpoints as stated in the above methodology. The results shows a clear variability in their magnitude and type of effects with more complicated health issues closed to the dumpsites (1st ring 0-500 m). It shows a gradual decreasing trend, more and more away from the dumping sites, i.e. ring of 500-1000 m has recorded moderate level of health problems and a comparatively less amount of ill-effects are seen in the ring 1000-1500 m. Accordingly, the volume and risk level of the health issues and distance from the solid waste dumps sites have a negative relationship. The two-way ANOVA test is applied to investigate the variable factors (distance, directions and location), comparing with constant factor (dumpsite). ANOVA Scheffe's test facilitated to deal with a comparison on solid waste related health issues, comparing with more than two variables, such as selected four study areas, different variable factors (distance, direction and location) *etc*. The results revealed that the nature, effects, size and volume of solid waste related health issues are varied qualitatively and quantitatively, according to the uneven elevations and other geographical factors. The geography of the area has become a deciding factor for health issues of the selected areas, which could be more or less. Accordingly, twenty three diseases were identified in the four selected study sites, and out of which the Colombo site had 45.6%, Kandy had 21.4%, Badulla had 17.6% and Kurunegala had 15.4% of health related issues.

a. Analysis on identification of health issues

Statistical data provided in the below table-1 clearly indicates that the health problems are different between the selected sites in terms of volume and type, due its elevation, topography, population density, public behavior and existing water bodies. Colombo and Badulla municipal waste dumping sites are located within their municipality limits; and Kandy and Kurunegala sites are located outside the municipal limits. Obviously, Colombo and Badulla municipal dumping sites are accompanied by residences, commercial buildings and various recreational activities, together with high population (both permanent and floating). The size of floating population in Colombo, Badulla, Kandy and Kurunegala are more than 550,000, 25,000, 100,000 and 250,000 persons/day respectively, which causes high solid waste generation and subsequently more vitality for health risk. Moreover, the Colombo study area has led to high prevalence of issues, according to the above table, since it has more residences exposed to the dumpsite with high population density. The frequency of respiratory diseases, such as headache, asthma, breathing difficulties, cough and wheezing are some of the dominant diseases, identified around the Kandy (Gohagoda) dumping site, due to its topographical features lacking the natural air purification process of the area.

Table-1: Identifications of health issues

	Diseases	Effected amount (%)			
No		**Colombo**	**Badulla**	**Kandy**	**Kurunegala**
01	Dysentery	20.6	32.5	18.3	28.6
02	Headache	39.0	24.7	19.4	16.9
03	Skin diseases	46.8	13.0	14.3	25.9
04	Burning eyes	43.2	28.3	20.9	7.6
05	Nausea	82.0	7.2	8.3	2.5
06	Irritation	58.7	18.5	15.2	7.6
07	Less sleeping	51.0	21.3	19.2	8.5
08	Asthma	37.7	6.5	42.2	13.3
09	Cough	44.2	24.0	13.6	18.2
10	Whooping cough	23.1	7.7	38.5	30.8
11	Wheezing	54.5	18.2	16.0	11.3
12	Dizziness	37.5	34.4	15.6	12.5
13	Fever with phlegm	47.3	22.1	19.5	11.1
14	Breathing difficulties	40.0	2.2	53.4	4.4
15	Dengue	41.2	3.2	47.6	8.0
16	Chikungunya	51.3	31.7	9.7	7.3
17	Hepatitis A	53.8	15.4	15.4	15.4
18	Diarrhea	15.4	15.4	7.7	61.5

19	Injuries	37.5	31.2	12.5	18.8
20	Dark skin (burns)	66.6	13.4	15.6	4.4
21	Itchy watery eyes	52.6	11.8	30.3	5.3
22	Sore throat	48.9	18.2	24.0	9.0
23	Viral warts	68.6	8.6	14.2	8.6
24	Others	52.6	11.8	30.3	5.3
	Total	**45.6**	**17.6**	**21.3**	**15.4**

Source: Field survey, 2016/2017.

In Kurunegala, communities around dumping site suffer from dysentery, kidney diseases, urine infection, cough and fever with phlegm, mostly caused by consuming contaminated water for various purpose. Similarly, it was found that dizziness, dysentery (stomach pain), plague (rat), injuries, burning of eyes and headaches are some of the prominent health problems in Badulla, however the comparatively less health issue have been found; since less waste generation (30-35 MT/day), less floating population (25,000 people/day) and surrounded by more commercial buildings than the residences. Further, some other health issues such as kidney diseases, blood pressure and urine infections have been discovered at 4%, in addition to the above identified twenty three illnesses.

This study tested the regular medical treatment obtained for various diseases in the selected study areas, which clearly shows the health conditions of people. Accordingly, dwellers living around Colombo (62%) and Kandy (63%) dumpsites obtain frequent treatment for various diseases, due to the prevalence of a high density of houses and lack of air purification process of the area. At the same time, people in the Kurunegala study area obtain less regular medical treatment (39%), compared to the other study area, due to their higher literacy level and most of them are employees of the government and the private sectors. This situation contributes to reduce the damage to human health, since they do not spend all the time in their own houses and reduces the air intake of the people. Moreover, they follow precautionary measures on health issues in their daily activities. However, the Badulla dumpsite is located at the center of the city with a dense population, yet most of them being educated and employed and manages their health better (34.3% uses mosquito nets), compared to the Colombo site. Finally, the results revealed that the physical environmental condition, the socio-economic and the cultural background have highly influenced the peoples' health in the selected study areas.

Table-2: Regular medications

Study areas	Regular medications-(%)	
	Yes	**No**
Colombo	62	38
Badulla	50	50
Kandy	63	37
Kurunegala	39	61

Source: Field survey, 2016/2017.

Below table-4 shows the results in each study area, based on the variable factors; such as distance, direction and location.

Table-3: Distance, direction and location of dumpsites and their impact on human health

Variables	Health impact (%)			
	Colombo	**Badulla**	**Kandy**	**Kurunegala**
Distance from dumpsite				
0-500m (1st ring)	54.0	60.2	52.8	60.3
500-1000m (2nd ring)	32.4	29.5	32.6	29.6
1000-1500m (3rd ring)	13.6	10.3	14.6	10.1
Direction from the dumpsite				
North	41.2	22.3	20.7	0.0
South	14.4	25.2	37.4	45.8
West	22.3	15.0	26.9	46.2

East	22.1	37.5	15.0	8.0
Location of residences				
Above the level of dumpsite	16.5	7.2	37.0	7.6
Below the level of dumpsite	28.5	31.2	40.5	68.2
Same level of dumpsite	55.0	61.6	22.5	24.2

Source: Field survey, 2016/17.

The above tabulated statistics were comparatively analysed vertically (distance, directions and location) and horizontally (study area wise health impacts). The distance wise analysis shows that 1st ring recorded high percentage of health risk in all study areas and it decreased gradually to 3rd ring, due to the negative relationship between distance and health issues. The pathological factors; such as water, food, mosquitoes, flies and other insects, spread in the dumpsite and have a direct interaction with surrounding dwellers are major reasons. Further, the population density, houses with poor facilities, low income of the people have led to aggravate health related problems in the 1st ring. Most of the people live close to the dumpsites are for the purpose of earning an income, who are largely waste pickers.

Further, the study identified that the effects of the health issues varied; according to the geographical directions, wind direction/circulation, vegetation cover and wind barriers; such as buildings and mountains. The Northern direction of Colombo study area records 41.2% of health related issues, since more residents together with the apartments are located in-between both Bloumendhal and Madhampitiya dumpsites. Eastern direction of Badulla had 37.5% of health impacts, due to dumpsite was situated in the middle of City area, surrounded with densely populated dwellings. The Southern direction of Kandy recorded 37.4% of health issues, since this direction is a low-lying area with more population, other directions are surrounded by mountains and leachates flows towards the downwards residential area. The both Southern and Western parts of the Kurunegala dumpsite have shown health effects at 45.8% and 46.2% respectively, since southern area is lowering to water bodies, more population, availability of agricultural lands and in the west more population and access road way to dumpsite is appeared in this direction.

The study observed that the residents around the dumps, waste pickers and waste collectors and drivers of waste carrying vehicles are major victims of multiple health effects. In addition, more susceptible and vulnerable groups are women and children, living in the surrounding area. The sex wise analysis of the collected data shows that great health damage had been suffered by female population (56.7%), rather than the male (43.3%), which will lead to bring out an unhealthy future generation, as a result of "unhealthy mother population" in the surrounding dumping sites. The pregnant ladies (13.6%), who live close to the open dumps suffer from various health problems, such as breathing difficulties (37.5%), lack of sleep (35%), skin rashes (15%), injuries (54%), headaches (16%) and other infectious diseases *etc*.

According to the public health inspector's data records regarding the children (including new born babies), more than 65.5% of them suffer from various illnesses. The increasing rate of respiratory diseases, skin rashes, infection diseases, allergies and stomach problems, headache, diarrhea, whooping cough, fever with phlegm and low weight in children are some of the dominant health effects, identified among the children in all the study areas. Thus, inadequate calorie/nutrient supply and poor hygiene have been observed in the child population in the surrounding dwellings, close to the dumpsites. The following Table-4 shows the health problems of children identified, around the dumping sites.

Table-4: Health issues of children in the selected study areas

Predominant diseases	Effected children (**below 12 years of age**)	Percentage (%)
Stomach pain	27	5.0
Headache	21	4.0
Skin rashes	36	7.0

Asthma/wheezing	53	10.5
Cough	76	15.0
Whooping cough	59	12.0
Fiver with phlegm	102	20.5
Skin diseases/rashes	61	12.0
Dengue	26	5.0
Diarrhea	19	4.0
Others	23	5.0

Source: Prepared by Author, based on the statistical data extracted from Public Health Inspector's records, 2017.

Table-4 displays the children population (below 12 years), those who have affected from different types of diseases in the selected four study areas. 236 (47%) children in Colombo, 137 (27%) in Badulla, 83(16.5%) in Kandy and 47 (9.55%) in Kurunegala were affected, due to the polluted environmental conditions. If this situation continues, child population will have to face severe problems in the future, such as increase of social cost, retardation of education, poor health and poor physical strength. Ultimately, these situations will adversely affect the socio-economic and cultural conditions of the area.

It was observed that, eight (08) schools were functioning close to the solid waste dumpsites, of them, five in Colombo and three in Badulla municipalities. According to the respective school principal information, an average of 85% of the children were affected, by different ailments in the Colombo and Kandy area, those who are living around the dumping sites were affected seriously by multiple health problems. The reasons for it are diseases causing germs, bad odour, dust and smoke, flies mosquitoes, polluted water and polluted air. Similarly, based on the information related to waste collectors and vehicle drivers, 70% of them suffer from different types of diseases, due to the waste related occupational activities. Most of the workers are affected by wheezing, skin rashes, chest pains, arm and neck pain, headaches, breathing difficulties and cough with phlegm.

In addition, the nuisances by stray dogs, mosquitoes, flies, birds, rodents, insects and bad odour with dust are generally experienced in all the study areas. 85% of the pubic complains have been made by the people of Colombo and Kandy areas with regard to the health issues and solid waste disposal. Reasons for the complaints were noted at the study, which indicates that the quality of the environment, climate, nature of the terrain, amount of waste generated, population density, level of income are the factors that affect people. Therefore, waste related issues are differed from place to place, depending on different geographical factors.

b. Comparative approach on study areas and health issues

ANOVA Scheffs's test method revealed the comparative results of the selected study areas and its significance of health issues. All four study areas have been comparatively analyzed, using three variables, *i.e*., distance, direction and location, along with six combinations of study areas as given in the table-5. Accordingly, the results have been driven 36 times (6 x 3 x 2) in different combination of the study areas. A few results show a significant variances pertaining to the geography and social phenomena, which considerably influence the solid waste related health issues. The significant results of ANOVA Scheffs's are reported in three ways as suggested by Coolican (1990, p.174), based on the probability/confidence level, which are 'significant' ($0.05 > p < 0.01$), 'high significant' ($0.01 > p < 0.001$), and 'very highly significant' ($0.001 > p$).

i. Distance wise comparison of health issues

ANOVA Scheffs's test was carried out to identify the correlation, among the study areas according to the distance from residence to the dumpsites at 99% of confidence levels and several significant results were arrived at, compared to the results of direction and location wise analysis. Almost identical effects between the distance and health issues were found in all study areas. Health issues seen in the first ring (0-500 m) situated very close to the dumps sites, were more numerous than elsewhere. But, it shows a gradually decreasing trend from the first ring (0-500 m) to the last ring (1000-1500 m). Therefore, the analysed results do not show much significant difference between the combinations of study areas stated in Table-5 below, except the Kandy/Badulla and Kurunegala/Badulla. But, it shows a significant p-value in the first ring (0-500 m) of Kandy/Badulla (0.012013175) and very high significant value in Kurunegala/Badulla combination (4.95021E-05), due to the influences of socio-environmental factors. Further, comparison between Kandy/Badulla shows a significant difference, among the health issues. It was observed that major health issues in the Kandy study area were viral warts, dark skin, and nausea, wheezing and breathing difficulties. This can be categorized under

respiratory and infectious diseases. But in Badulla, there were dysentery, irritation, burning eyes, dizziness and headache which are mostly fungal, bacterial or viral infections, caused by the existing contaminated environmental background of the surrounding area. Low income earning people reside very close to the Kandy dumping site, they being waste pickers, who spend entire day time in the waste dumping site to collect various re-usable wastes from the site without having any precautions. Badulla dumping site is situated in the center of the city. The surrounding atmosphere is contaminated, due to the waste dumping site and range of mountains around and prevent air purification process in both (Badulla and Kandy) areas.

The below comparison between Kurunegala and Badulla study area shows a very high significant result in respect of the health issues in the first ring (0-500 m). At Kurunegala, some common childrens' health problems; such as lack of sleep, whooping cough, fever with phlegm and diarrhea were to be seen.

Table-5: Distance wise comparison of health issue (p-value)

Variables	Colombo-Kandy	Colombo-Kurunegala	Colombo-Badulla	Kandy-Kurunegala	Kandy-Badulla	Kurunegala-Badulla
Among diseases	0.32968	0.11071	0.27191	0.08614	**0.01201**	**0.00005**
0-500 m/diseases	0.92569	0.08275	0.28080	0.14716	0.23459	0.62874
Among diseases	**0.02084**	0.07271	0.33375	0.07226	**0.04138**	**0.00068**
500-1000m/ diseases	0.38038	0.80903	0.79518	0.60609	0.63943	0.93912
Among diseases	0.36320	0.82014	0.83602	0.36086	0.72054	**0.00966**
1000m-1500m/ diseases	0.28474	**0.00861**	0.10094	0.09648	0.37884	0.60283

Source: Field survey, 2016/2017

Further, during the rainy season; the runoff water takes solid and liquid waste from the dumps site along with the pollutants to the underground and surface water bodies downstream, from a geographical point of view, continuous process in this nature will cause the water borne diseases and viral infection in the dwellers around the site.

The study compares the distances and health issues of the second ring (500-1000 m), which shows a significant p-value among the different health issues. The combination of study area Colombo/Kandy (0.020835087) and Kandy/Badulla (0.041384097) record significant results, but in Kurunegala/Badulla the combination shows a very high significant result (0.000677114) in the second ring, in the health issues. Thus, a comparison of Colombo/Kandy shows a high percentage of inhabitants suffer, due to the contamination of air and dust of the vicinity. Therefore, asthma, whooping cough, wheezing and dizziness could be seen generally, among the people.

The major reason for this is inhaling contaminated air; especially as the second ring of the Kandy site is lacking of air purification, since the study area is surrounded by mountains. Further, it was observed on the Colombo sites that the occupants had dark skin, injuries, itchy watering eyes, asthma, burning eyes and nausea, especially in the second ring. The causes of this are dusty air, insufficient precautions from mosquito bite, lack of care to prevent contamination of food, high density of low income earning population and poor housing conditions. Therefore, it is recorded in these two study areas that more and more are afflicted with various types of diseases. Due to these reasons, a combination of Colombo/Kandy shows significant p-values (0.020835087), among the diseases. But, the Kurunegala/Badulla combination shows a very high significant result among the health issues in the second ring. Dizziness, headaches and burning of eyes are some dominant issues in the Badulla area, due to lack of air purification, but in Kurunegala area suffered from mostly by water borne infections, such as skin rashes, nausea, whooping cough, diarrhea and hepatitis, due to use of contaminated water.

In the third ring (1000-1500 m), a comparative analysis of Colombo/Kurunegala and Kurunegala/Badulla, was carried out, which reveals a high by significant result as 0.008614481 and 0.00965501 respectively. Other four combinations of the study areas stated above do not show a significant result, pertaining to distance and health issues. Big variances are to be seen in the third ring of the Colombo/Kurunegala study areas. Third ring of Colombo study area recorded a high percentage of health issues, due to the impact of two dumping sites (Bluoemendhal and Madampitiya), which were located very close to the residential areas. But, when compared with the Colombo study area, the third ring of Kurunegala site recorded a lesser amount of health issues and fairly good socio-economic background, since it is close to the Kurunegala town area.

Further, the above Table-5 does not show any significance in between the combinations of Colombo/Badulla and Kandy/Kurunegala study areas, due to the same characteristics of the environmental and socio-economic conditions. Subsequently, the above mentioned health issues clearly revealed that different geographical backgrounds influenced the results.

ii. Direction wise comparison of health issues

ANOVA Scheffs's test has also been used for the direction wise comparative analysis of health issues. Accordingly, the Northern direction of the Colombo site showed 41.2% of health issues. Thus, the Eastern direction of the Badulla site recorded 37.5%, Southern direction of Kandy recorded 37.4% and Southern and Western directions of Kurunegala accounted the 45.3% and 46.2% of health issues respectively. Above stated directions consisted of high density of residential houses, schools, religious places, cultivated lands, catchment areas of water bodies, and high floating population which have become reasons for recording a high volume of health issues in the above directions, compared to the other directions of the respective study areas.

According to the Table-6 below, the combination of Colombo/Kandy shows a very high significant result on the directions of North (7.88181E08) and South (5.50412E-06). Colombo/Kurunegala also shows a very high significant p-value- in its Northern (3.32761E-18), Southern (5.29638E-11) and Western (1.9481E-08) directions. Similarly, Colombo/Badulla shows very high significant results in its Southern (0.037809038) direction. Kurunegala/Kandy shows very high significant p-value in the Northern (7.92965E-08) and Western (9.76158E-06) directions. Kandy/Badulla also records very high significant p-value in the Southern (9.3702E-05), and Eastern (1.3333E-05) directions and the Western direction shows a significant result (0.053566112). Kurunegala/Badulla combination shows very high significant results in the Southern (2.24223E-06), Western (5.40855E-06) and Eastern (2.28505E-06) directions.

Further, combination of Colombo/Kandy, Colombo/Kurunegala and Kurunegala/Kandy do not show a significant result in their Eastern directions. Thus, Kandy/Badulla and Kurunegala/Badulla have not shown significant results in the Northern direction. However, the combination of Colombo/Badulla study area has shown a significant p-value in the Southern direction only and other three directions do not show any significant result. Both, Colombo and Badulla dump locations are situated within the municipality limits and exhibit almost the same socio-economic features. Therefore, it does not show a significant variance.

Table-6: Direction wise comparison of health issue (p-value)

Directions	Colombo-Kandy	Colombo-Kurunegala	Colombo-Badulla	Kurunegala-Kandy	Kandy-Badulla	Kurunegala-Badulla
Among diseases	0.342749105	0.5000000	0.49653203	0.5000000	0.498122175	0.5000000
Northern direction/ diseases	**7.88E-08**	**3.33E-18**	0.379181715	**7.93E-08**	0.305572797	0.249410394
Among diseases	0.761174626	0.514096307	0.957671724	0.746448034	**0.042102202**	0.692864532
Southern direction/ diseases	**5.50E-06**	**5.30E-11**	**0.037809038**	0.211441626	**937E-05**	**2.24E-06**
Among diseases	0.983064744	0.187586318	0.125474016	0.086543329	0.96145346	0.304229331
Western direction/ diseases	0.128211916	**1.95E-08**	0.131842469	**9.76E-06**	**0.053566112**	**5.41E-06**
Among diseases	0.531346618	0.527429587	0.456724826	0.847665602	0.431564279	0.667210559
Eastern direction / diseases	0.269629766	0.255169661	0.432247434	0.557962338	**1.33E-05**	**2.29E-06**

Source: Field survey, 2016/2017

iii. Location wise comparison of health issues

The comparative analysis of all the selected study areas and its location wise health issues was carried out at 99% confidence levels and showed a significant results, due to the large variance of the topography, among the selected study areas. More residential areas situated at in the same level of Colombo and Badulla dumping sites were significantly affected with health issues (Colombo-55% and Badulla-61.6%). Similarly, the study areas of Kandy (40.5%) and Kurunegala (68.2%) showed a higher number of health issues, where

residences were located below the level from the dumping sites. The topography of the Colombo site shows almost a low-lying flat land area, but Badulla has a basin type plain topographical feature. The dwellers around the Kandy and Kurunegala dumpsites were particularly vulnerable below the level of the dumpsite. Therefore, it is a fact that the impact on health of people was adverse owing to the geographical factors.

Table-7: Location wise comparison of health issues (p-value)

Location	Colombo-Kandy	Colombo-Kurunegala	Colombo-Badulla	Kurunegala-Kandy	Kandy-Badulla	Kurunegala-Badulla
Among diseases	0.986788508	0.535540634	0.292039893	0.069895349	0.219115016	**0.0366569**
Above level/ diseases	**0.05254125**	**0.01428389**	**0.01236321**	**1.66E-07**	**1.44E-06**	0.926081874
Among diseases	0.215243614	0.499268833	0.356201881	0.864358647	0.577716237	0.855717638
Same level/ diseases	**0.00152662**	**0.02058578**	0.402199616	**0.05416683**	**1.28E-07**	**0.0007364**
Among diseases	0.768844841	0.311800591	0.714085175	0.990481316	0.79072366	0.233731715
Below level/diseases	**0.02995877**	**4.82E-07**	0.571595422	**0.00620381**	0.124724063	**6.33E-06**

Source: Field survey, 2016/2017

The above analysis referred to the combination of Colombo/Kandy show their significant p-value, pertaining to the locations of the dwellings, above the dump (0.052541251), same level (0.001526623) and below (0.029958774). But, a high significant result is seen at the same level (0.001526623), where houses and the dumpsite are located at the same elevation. A higher number of health issues were recorded at the same level on the Colombo sites, but on the Kandy site the numbers were few, due to the hilly topography.

The combination of Colombo/Kurunegala study area shows a significant result in the level above the dump (0.014283886) and same level as the dump (0.020585781). A very high significant p-value (4.81898E-07) with regard to the residential locations has been shown in the level below the dumpsite, due to the numerous health issues, recorded at this level in Kurunegala, than at the Colombo site. The combination of Colombo/ Badulla shows a significant p-value (0.012363205) on the level above the dumpsite. But, this combination does not show much variance, due to the same kind of surrounding vicinity. When compared to Badulla; the number of residences situated above the level of dumpsite in Colombo is a little high, due to the high level of the flats/houses. These houses are also considered as residential houses, located above the level from the dumping site which is considered as an artificial elevation range.

The combination of Kurunegala/Kandy shows p-values of the level above, same and below the dumps to be 1.66277E-07, 0.054166831 and 0.006203807 respectively. The residences located above the level of the dumpsite, recorded a very high significant p-value, due to the different geographical features of Kurunegala and Kandy study areas. Specially, houses situated above the level of Kandy dumpsite show a significant number of health issues than the houses situated above the level of Kurunegala site. The major reason for low amount of health issues, recorded at the level above dumpsite of Kurunegala is forest plantation, which is situated above the level of dumping site. Further, the combination of the level below the dumpsites of the same combination of the study area also shows a high significant p-value (0.006203807), due to high population density, which is present at the level below dumpsite in Kurunegala than the Kandy site. The population density is a reason to record many health issues on the Kurunegala site.

The Kandy/Badulla comparison shows a very high significant result on the level above the site (1.43777E-06) and at same level (1.28419E-07) of a dwelling in relation to the dumping sites. Based on the topographical features, the houses located above the levels of the dumpsite of Gohagoda-Kandy, recorded more health related issues, rather than the level above of the Badulla site. On the Badulla site, there were many dwellers at the same level of housing units from the dumping site which shows a very high significant result over the Kandy site. It is clear that above mentioned results of the two combinations proved that the different geographical backgrounds influenced the health conditions of the occupants of Kandy/Badulla at different angles.

Finally, the combination of Kurunegala/Badulla shows a significant p-value (0.036656877) on the level above from the dumpsite. Further, same level and the level below houses from the dumpsite show very high significant results, 0.000736406, 6.33164E-06 respectively. Further, the Kandy/Badulla comparison shows a very high significant result on the level above (1.43777E-06) and the same level (1.28419E-07) of dwellers from the dumpsites. However, the Colombo/Badulla shows only a significant value in the level above (0.012363205) of houses from the dumpsite. Health issues on the level above the dump on the Colombo site recorded, 16.5% and Badulla site recorded, 7.2%. The Colombo site many adverse consequences to health, since more and more shanties have been constructed, around the dumping sites which are considered to be above the level of the dumping site.

In addition, the "correlation" shows significant results between Colombo and Kurunegala dumping sites, which is -0.560. Similarly, the correlation between Badulla and Kandy also shows a significant result (-0.607). The Figure-5.1 clearly illustrates the value of the "Pearson Correlation" test on human health issues of above study areas. Further, the above mentioned combinations of the study areas belonged to different AEZ, which have different geographical characteristics. Therefore, it gives the significant results on the analysis of correlation of all the four selected study areas.

Majority of the health issues are present on Colombo dumping site, than the other three sites, due its socio-environmental factors. Communicable and non-communicable diseases play a major role in an inhospitable environment, due to the disposal of large amount of waste on a daily basis. Further; Badulla, Kurunegala and Kandy show a high incidence of water, air and vector borne diseases. The results clearly reveal that the impact of socio-environment and geographical characteristics are major factor of determining various health problems of the dwellers, around the selected dumping sites. The comparisons in the above mentioned study areas integrated with different geographical backgrounds and two of them are located within the municipal limits (Colombo/Badulla) and the other two (Kurunegala/Kandy) out of the municipal limits show different health issues.

VI. CONCLUSION AND RECOMMENDATIONS FOR IMPLEMENTATION OF SOLID WASTE MANAGEMENT STRATEGIES

6.1: Conclusion

All the waste generating activities lead to discharge residuals to the waste stream, which cannot be prevented with growing population and development activities. These cyclical issues have to be managed at a middle point. This study found that although the existing urban environmental issues are almost same in the selected study areas; the nature, effects, size and volume of the issues are varied, due to uneven geographical distribution. Thus, the results show a clear variability in human health related issues, according to the distance, direction and location from the respective waste dumpsite, similar rings of different dumpsites, and also amongst the four different selected study areas, as the geographical factors play an important role.

This study highlighted a few areas to minimize and manage the solid waste related health issues by way of minimizing the waste at source, sorting, collections, transportation, disposal, encouragement of home compositing system, post disposal site management activities, stakeholders' participation, introducing a uniform practice of SWM for all local governments by consolidating their powers to a center point (*i.e.*, National Environmental Forum-NEF) and rehabilitation of existing and abandon disposal sites. Conducting public education and awareness change in public attitudes and behaviours, correct site selection following proper procedures, social and public acceptability of such sites, finding a solution to control imports with more packing materials are also included in the provided recommendations.

Further, this study proposes to establish National Environmental Forum (NEF), prepare a National Master Plan (NMP) for ISWM, establishment of special Waste Management Act and National Environmental Conservation Fund (NECF). In addition, introduction of Environmental Conservation Tax on imports, establishment of special Environmental Protection Task Force (EPTF) to monitor anti-environmental/illegal activities and avenues for revenue generation of LAs have also been discussed in this study.

Finally, the right solutions were provided to implement an ISWM process by each and every LA, consolidating all the relevant resources including key stakeholders, who are responsible for waste management practices, under the proposed NMP for integrated waste management. This plan must be included in operational and monitoring guidelines to ensure its sustainability and ongoing large public services system, which need to be efficiently provided to the community to maintain aesthetics and public health standards. There has to be a

systematic effort by the local governments, in the improvement of various factors, such as institutional arrangement, financial provisions, appropriate technology, operational management, human resources development, public participation and awareness and policy and legal framework for an ISWM..

6.2. Recommendations

i. Inference of integrated waste management system

This study recommended preparing ISWM; considering the respective urban areas environmental and socio-economic background, amounting of waste generation, collection and existing disposal mechanism. Accordingly, all related factors/functions of waste management hierarchy should be integrated into a common point *i.e.*, Deputy municipal commissioner (Engineering services) or Chief Medical Officer, as aspirate to monitor and manage the waste management activities from top to bottom. However, the operational responsibilities of respective municipality would be delegated to each of municipal administrative districts or zones, eg: Colombo (5 Administrative Districts) and Kandy (5 Administrative Zones), Badulla (3 Administrative Zones) and Kurunegala (6 Administrative Zones).

Municipal authorities are responsible for range of different functions. These are performed or managed by many different sections of the authority, often with limited infrastructures and financial resources. Existing legal and institutional frameworks in relation to environmental management will provide necessary guidelines, pertaining to the functional operations of LAs and establish suitable policies and plans. On the other hand, different stakeholders involve in environmental and solid waste management (SWM) activities with different scope, which will sometime become duplication of the same works. Further, general public has a perception that SWM is a sole responsibility of respective LAs only and also they do not show more interest to participate or they were not provided sufficient opportunities to engage in SWM activities. Therefore, an ISWM system, combining all stakeholders under the jurisdiction of one single institution, *i.e.* proposed NEF, is required. This forum will provide a clear division of roles and responsibilities in waste management to establish transparent procedures, contracting out waste management services and all other waste management activities. Similarly, functional/operational activities, plans, policies, process and related provisions of existing laws of SWM should be addressed by the NMP for integrated waste management. Accordingly, this study suggested to bring related stakeholders and waste management functions, under the authorities of NEF and NMP respectively. In addition, this will offer a tool to improve the consistency and coherence between different components from an environmental perspective, along with public involvement and acceptance. Similarly, NMP for waste management will provide necessary directions in relation to SWM and maintain uniformity among the all LAs in Sri Lanka.

ii. Establishment of National Environmental Forum

This study encountered lack of cooperation among the stakeholders, lack of implication of existing environment related regulations and financial deficiency, which adversely influence the efficient waste management system in Sri Lanka. Therefore, the study proposes National Environmental Forum (NEF), which should be exclusively responsible for all waste management activities in Sri Lanka. As a supreme body, all agencies, who engage in the environmental management activities, whether it is biology, geology, hydrology or climatology should be handled by this forum. This Forum should be formed, with the participation of relevant stakeholders, under the direct supervision of concerned Minister, which includes members from all Ministries of environmental concerned (*eg.*, Ministry of environment and natural resources, Ministry of provincial council, Ministry of urban development and Ministry of defense), Central Environmental Authority (CEA), Waste Management Authority (Western Province), Police, Hospitals, Private Institutions (*e.g.*, Abans), Community Based Organizations and NGOs (*e.g.*, Environmental Foundation Ltd) *etc*.

NEF is a apex approving authority for all national level environmental related projects and plans. This forum will approve any project, after consulting all stake holders' opinion of this forum. A productive constitutions should be legalized, elaborating all responsibilities.

iii. National waste management programme

NEF, its prime duty is to prepare a National Master Plan (NMP) for integrated solid waste management. Guidelines of proposed NMP should be properly reviewed and evaluated by the expertise team in waste management and approval of NEF is essential for implementation of this programme.

iv. Health Impact Risk Assessment

This study proposed Health Impact Risk Assessment (HIRA) report, along with an EIA is required to implement any development or waste related project, i.e. any development activities causing more environmental damages is required both EIA and HIRA.

v. Environmental Protection Task Force

This study propose special EPTF to implement the existing law. Currently every police station has environmental Unit, which should be further upgraded with more responsibilities and delegation of powers.

vi. National Environmental Conservation Fund

This study further recommend to establish a NECF and funds should be generated *via*. enforcing Environmental Conservation Tax on all imports with more waste/harmful waste. Tax exempted donations, foreign aids, state budgetary allocations and any other income sources would be avenue of revenue of this funs

vii. Paradigms shift for effective waste management

According to the analysis of this study, each step involved in the urban solid waste management should be carefully evaluated, following micro level approach at all steps listed below and take suitable decision by respective LAs.

1. **Waste generation:** Only viable option to mitigate the waste generation is at the starting point. This is possible by implementing continuous public education and awareness, distribution of compost bins, compost preparation and collecting recyclable/reusable items by waste workers/waste collectors for re-sale/re-use.
2. **Waste sorting:** The second functional aspect of the SWM process is waste sorting and storage at the source. Households should be made aware of the importance of separating paper/cardboard, bottles/glass, polythene/plastic, iron /steel and biodegradable waste. After sorting, reusable and recyclable waste can be sold to collecting centers by the households or can be handed over to the municipal waste workers for collecting such recyclable waste for further useful process.
3. **Waste collections:** Establishment of a proper waste collection mechanism with the segregation of biodegradable, non-biodegradable, recyclable, non-recyclable, hazardous and non-hazardous waste is essential with the support of related stakeholders. It is advised to have an individual plan for waste sorting, collection, transportation and disposal; taking into consideration the socio-economic and environmental background of respective areas by each LAs. Biodegradable and non-biodegradable waste should be collected, transported and disposed separately, which should not be allowed to mix together at any stage.
4. **Waste transportation:** The waste transportation process comprises drivers, vehicles, vehicle parking, garage, maintenance, route plan and maximum utilization of available resources. Considering this, a proper plan with regard to waste transportation should be prepared for each LA; taking into consideration the road network, topography, volume of waste generated, manpower and distance from the household to dumpsite.
5. **Waste disposal:** The disposal site should be organized and managed by a site controlling officer, according to a plan; ensuring maximum utilization of land, reduce traffic congestion and facilitate smooth operations (compaction, proper spreading and covering with soil etc). It was observed that no controlling officers have been deployed in the all sites and waste were haphazardly dumped.

viii. Promote home composting

Home composting is a way of reducing waste reaching the waste disposal site. Possible, LAs must consider household composting as an acceptable method of bio-degradable waste. The public should be encouraged to maintain household composting units, which should be distributed by the municipal authority at a concession rate.

ix. Environmental education and awareness

Environmental education and awareness is one of the most powerful, effective and less costly tool for SWM, which will definitely produce sustainable results. A continuous awareness raising programme for stakeholders in order to obtain their active participation and support for implementing waste management programme is vital to share knowledge, value, skills, experience and the determination, which will enable them to act individually and collectively to resolve present and future solid waste related issues.

Such awareness raising programs could be launched through schools, community organizations, women's societies, industrial and commercial sectors and LAs to encourage the 7Rs process (**r**efuse, **r**educe, **r**euse **r**ecovery, **r**ecycle, **r**ethink, and **r**esidual waste). It is important to review and further strengthen the existing schools and university curriculum of environmental education to enable individuals to acquire the

knowledge from childhood. Further, it should be extended to the households, waste collectors, waste pickers and other staff too. Obviously, environmental friendly attitudes of the general public would positively change both public and environmental health. In this context, the education and awareness will play a major role.

x. Public attitudes or Behavioral change

Changing public attitudes and behavioural pattern, correct education and awareness towards environmental conscious attitudes are effective options for waste minimizations and management. Therefore, it is vital to have a longer scale programme to change public attitudes and behaviours. In this context, environmental education and awareness has become a major tool to achieve this objective.

xi. Rehabilitation of existing dumpsites

Systematic rehabilitation process should be introduced to manage abandoned, poorly designed or improperly operated waste dumpsites. Frequent monitoring of all such waste dump sites is required to identify the possible health hazards to the environment and human lives and to convert them as a better standard site for reusing as a disposal spot in future. This study is clear that the potential for rehabilitation should be further pursued and continued by technically trained personnel of municipal engineering division, whose responsibility is to ensure a satisfactory operation of upgraded dump sites.

xii. Site selection and management

The site selection is a complex procedure, which involves evaluating numerous factors, such as environmental, political, financial, economical, hydrological, topographical, geological, existing regulations and engineering/technical. Moreover, highly populated areas should be excluded from selection as dumpsites/landfill to safeguard the environment and human health. Further, dumpsites should not be located within 500 m from rivers, lakes, flood plains (hydrological zone), densely populated and environmentally sensitive areas. Paying more attention to the related factors and selecting a proper waste disposal site will minimize the environmental destruction, ensure the aesthetic beauty of the area, maintain land values and reduce the health issues. EIA, HIRA and SWOT analysis should be applied to identify the suitability of the area as a disposal site. This is very essential tool to minimize environmental impacts, human health impacts and operational problems.

xiii. Institutional backgrounds

Although, there are numerous environmental related institutions, both in the private and public sectors; they have their own and particular agendas and objectives. Sometimes, the activities are contradictory, among two institutions as regards some issues and also a particular institution may state that a particular job does not come within their purview. Some institutions carry out development activities without any environmental concern. There is also duplication of functions. This situation hinders any common activity to move forward, towards a common objective. Therefore, all the environmental related institutions of both government and private sectors should be amalgamated under one common corporate body (ie. NEF) to move forward to achieve a common objective.

xiv. Legal background

The exiting legal frame work, pertaining to the environment should be examined and amended, according to current requirements. The relevant amendments and addendums should be incorporated into the principal legislation. In addition, enforcement of separate waste management legislation, covering entire process of waste management is essential. Existing laws are strictly to be implemented, without any bias by proposed special EPTF, established under Sri Lanka Police Force.

xv. Policies and Plans

Municipal authorities must have a proper plan with community participation, to resolve the community needs within the framework of using available resources; staff, equipments and facility utilization, environmental protection and having an effective and efficient waste management system. In the context of above, the proposed NMP for waste management should be prepared as a guide for both private and public authorities, incorporating all recommendations made in this study. This plan must address environmental protection in its first section, waste management procedures in the second section and sustainable approach for environmental management, including human health and environmental management in its third part. Final part should be dealt with revenue generation for waste management. This would be an operational and management manual and control approach for all stakeholders, in terms of SWM. Guidelines provided in this plan can be used for preparing its own waste management plan of individual LAs, according to its socio-environmental background. Sustainable SWM cannot be achieved through isolated approaches, for an example, by a number of isolated projects or applying technology or isolated awareness programs or with different activities of

different stakeholders. All these activities should be consolidated, under the NMP for waste management and should be discharged, as a collective force, with a wide range of activities, to manage these recurring solid waste related issues in the all selected study areas.

xvi. Stakeholders' participation

A single person, a single institution or government alone cannot resolve solid waste related issues in sustainable manner. Combination of all stakeholders such as general public, LAs, private waste handlers, employees of LAs, provincial councils and the central government, NGOs, community based organizations, industries that generate waste, recycling industries, commercial establishments, waste pickers, scrap dealers, consultants, financial institutions, media, citizens, self-help groups and waste processing and disposal organizations *etc*. should be consolidated to a focal point, under proposed NEF to provide productive solution for this national issue.

xvii. Financial support

Proper management of urban solid waste needs sufficient financial and economic foundations. Government allocates funds in its annual budget, which is not sufficient for the entire waste management process. Therefore, revenue generative strategies are required to enhance the financial stabilities of all LAs and to establish a fund for environmental conservation. The necessary funds should be generated domestically and internationally and the particular funds should be collected to an account, which can be named as NECF. This fund should be used nationally for environmental conservation and management purpose only. The sole governing body of this fund should be the above stated NEF. Any contribution to this fund should be exempted from income tax. Contributions can be deducted once from taxable income. Suggested, enforcement of an "Environmental Conservation Tax (ECT)" on all commercial imports, contributes largely to add more accumulations to the waste stream. This tax revenue should be transferred to the NECF.

xviii. Inspiration of multi research activities

Currently, the amount of SWM related researches have been conducted and also provided various suggestion and recommendations; but, solid waste related issues are still being continued and apparent to be unresolvable. Major issues are human health effects, which should be addressed in a sensitive manner, applying micro-level approaches. Therefore, **mix of both scientific and social research approaches** is required to analyse existing human and environmental health issues and to provide most suitable consolidated suggestions. This research should address all the environmental related issues, such as water contamination, due to the emission of leachate, noise pollution and disturbances of animals/birds and identification of socio-environmental impacts, including visible health problems and conducting waste management projects/programs.

Further, the current study found various health issues with the help of occupants, waste workers and waste pickers; but, some of these people have fallen into the diseases and some other issues are actually not diseases, they are symptoms of serious health damage. Therefore, further research in this connection is needed in-depth with scientific or medical approach. In addition, a separate research into the psychological characteristics of the communities, who live near the dumpsites, should be carried out. Although, the natural science aspects has been dealt very much with the crisis of solid waste and water pollution, the relevant geographical factors too should be incorporated into the future studies, which will be helpful to understand the actual subjective factors of solid waste disposal and water pollution. Therefore, it is necessary to emphasize that geographical approach can realize subjective causes and effects of the solid waste disposal.

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