A Pilot Case Study Reviewing Possibility of Applying Onsite Sorting to Assist Management of Construction Solid Waste in Khartoum, Sudan

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Abstract— Construction industry has a significant impact on the environment. The outcome of the disposal of construction solid waste (csw) in landfills and the large space occupied by it, have created a serious problem, and raised the challenge for managing it. In order to achieve proper waste minimization, the 3Rs management method(reduce, reuse, and recycle) is proved to be successful in many previous studies. The method is more effective when csw is sorted. A pilot study is made in Khartoum state to reflect the possibility of applying onsite sorting method, and to know the level of awareness of the construction team towards it. A questionnaire introduced using key indicators from a previous study for onsite sorting. The survey reflected the factors affecting the process of onsite sorting. Sorting is approved but contractors disagree on onsite sorting, due to interrupting construction activities.

Index Terms— construction solid waste management, key factors, onsite sorting, 3Rs concept.

1 INTRODUCTION

AS environmental deterioration got the attention of governments and private sectors worldwide, the responses towards managing waste, sustainability and green architecture due to pollution has increased. The increasing growth of population and urbanization in Khartoum state, Sudan, led to expansion in the construction industry. Which triggered accumulation of csw. Huge amount of uncollected waste on open spaces created nuisance and polluted the local environment. Therefore, frequent waste removal for avoiding unsightly and unhygienic surroundings is necessary. In a resource efficient economy and society, the term 'waste' would refer only to materials that have no potential to be utilized and, therefore are of no economic value.

According to some studies,[1], csw is responsible for up to 50% of climate change, 40% of energy usage globally, and 50% of landfill waste, and not to mention air, water and noise pollution, destruction of natural habitats and construction climate challenge,2019,

Khartoum the capital of Sudan and the largest city. It is situated in the middle areas of the Sudan, between 15 and 16 degrees latitude north, and 31 and 32 degrees longitude east.

Khartoum State is the most densely populated area in Sudan, with a size of around 22,122 Km2. The population census was estimated as 5,274,321 capita, with various tribes in 2008. The urban population represented 79%, 74%of which were reported of rural origin, [2]. The population has increased to about 6,270,000 people in 2012, [3].The scientific & technical journal, Bjstr, stated that the population in Khartoum city has reached 8million in the year 2018 [4].

Management application is a difficult task; as csw can rise at any stage of the building process, besides the different nature of each project. Although it has been stated in the laws of Ministry of Urban Planning in 2008[4], several conditions have to be fulfilled related to building construction through the administration of public road infraction. It is not allowed to occupy the road with any of the csw, unless with permit.

Records regarding waste in the construction field are few in Khartoum. Unfortunately till 2020 the country still lacks the official proper solid waste segregation and all types of waste are dumped together. The problem of csw accumulation is increasing and weak management is undergoing beside the economic effect

2 LITERATURE SURVEY

The lack of proper waste disposal system generated accumulation of huge volume of construction waste materials in open areas, dumpsites and landfills. according to Japan International Corporation Agency (JICA) report in 2014 [3], around 5,000 ton of waste is generated in a day in Khartoum State. This raised an environmental problem, which remained neglected due to economic factors in area of study. The csw, as one of the types of solid waste which lack proper management and needs special attention.

A survey by Tahani [5] about waste sorting was suggested as part of the solution and the amount was presented as a segregated percentages in the year 2008, when a contract was signed between Khartoum State Cleaning Project (KSCP) and a British company "Environmental Consultants and Services",(ECS) for constructing and operating a new landfill located in West Omdurman(Khartoum city). One of the objectives of the project was Separation and recycling of plastic. Some of the sorted items are shown below as percentages of total segregated items.

Table 1, Components of Municipal Waste in Khartoum City KSCP,2008.

Component	Percentage
Paper	34.40
Organic Mather	32.60
Plastic	15.30
Sand	7.40
Glass	3.50
Textiles	2.60
Metal	1.70
Rubber	1.60
Wood	0.40
Leather	0.30
Aluminum	0.05

The table shows high percentages of paper, plastics, and organic matters. These are the types that were managed at that time, as being profitable. Therefore it was a priority in segregation. Unfortunately this sorting of solid waste had been practiced only for a certain period of time.

The waste collection crews informally practiced a sort of waste separation during waste collection, [5]. The csw was collected with the solid waste. Labor selected only the useful items from the waste, such as electrical devices, metal cans, plastic bottles and other types of waste csw that might be an additional income for them. The waste was carried in special bags and with pre-arrangement with the vehicle driver, they stop in certain locations to sell it, is called waste merchants. But these were not registered officially.

Another survey was implemented by Bjstr journal(2018) [5] about landfills, Tayba Al Hassanat, Khartoum. The report concluded that, roads were one of the obstacles that waste truck drivers faces during waste collection, either due to improper roads which hinder reaching some areas or to debris accumulated in front of construction sites which made the road too narrow for the vehicle to pass through. Especially at rainy seasons difficulty of driving forced the vehicle driver to randomly dump waste outside the landfill. Trucks reaching landfills undergo un official segregation which is carried out during unloading of trucks randomly by scavengers, mostly looking for plastic bottles which were sold to recycling companies. Unfortunately safety factors are considered to be very low for those collectors.

2.1 Major Cause for Waste Accumulation

To improve the quality of life through environment and health aspects, all factors related to waste reduction have to be included in managing csw and to be applicable. To achieve this goal, all factors causing the waste accumulation have to be identified. these following factors are:

a-Waste collection, transport, and disposal are on act, but not enough, due to facilities required; vehicles need maintenance, equipment, personnel awareness, and less supervision.

b-Landfills, takes more than its capacity and becomes more like dumping sites. While random burning is carried on to reduce the amount of waste.

c-Collectors on landfills or dumpsites cause waste spread when searching for the items to sell.

d-No official sorting.

Therefore, the problem of csw in Khartoum due to illegal dumping of waste , un proper sorting which result in big amounts of waste going to landfills, and csw being mixed with the solid waste which destroy and contaminate the waste material.

Csw is not beneficial if mixed with other type, contaminated or destroyed, this is avoidable only if sorting process is carried out. Therefore separation of csw from solid waste and sorting it before reaching landfills.

A study survey is conducted to reflect the problem. These issues will be considered in a pilot study.

3 Pilot Study Approach

The pilot study focuses on the following measures;

a- Csw is not beneficial if mixed, so onsite sorting must be applied,

b-The level of awareness of the construction team (contractors, architects, & labor) with regard to the csw onsite sorting in order to be able to apply 3Rs management process.

Questionnaires are used to show the contribution of the construction team to the csw management. Normally this approach is used for assessing the effectiveness of waste management in construction projects, when resources are limited, it make it easier and more efficient to manage the factors (Chen et.al.,2007& Lu et al., 2008).[6]. The application of critical success factor, CSF, (i.e. key factor or selected success factors, ssf,) is a proper approach to the field of construction management. As it indicates, its great potential for the identification of the vital factors to help to reduce the complex nature among several issues.

The application of the Selected Success Factors SSFs is preferred and practiced for onsite sorting of construction waste as stated by Jiayuan, 2009& 2010, published. economical factor is added by the author as the tenth factor, because it is the reason of delaying csw management in Khartoum state.

3.1 Methodology

The questionnaires distributed to respondents with minimum 5 years of experience. The respondents included few architects and majority of contractors, because contractors are always on site and experience the csw problem. Questionnaires were distributed to 56 respondents, (nearly above half of the number of construction companies in Khartoum state). Different approaches of communication were used which are direct, email and what sap according to the respondent preference. Following is a sample of questionnaire;

Fig:1-pilot study, questionnaire,

Pilot study questionnaire,2016

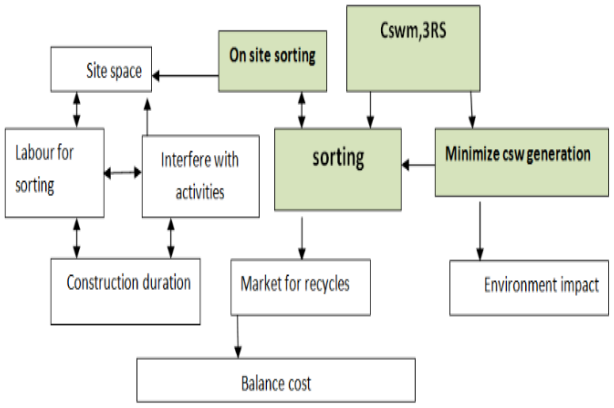
Then these factors were evaluated according to their effect on csw sorting process by ranking from 1-5, score 1 is to the lowest level with low effect on the csw sorting, ascending to level 5 for the highest effect, and the scores in between rank medium:

- **SF1: labor for on-site sorting of construction waste,**
- **SF2: development of Market for recycled materials,**
- **SF3: waste sort ability, it was difficult to separate the wasted materials after they were mixed.**
- **SF4:The role of management in minimizing the generation of construction waste, better management**
- **SF5: site space, for onsite sorting**
- **SF6: equipment required for sorting of construction waste,**
- **SF7: Environmental considerations dust and noise**
- **SF8: Interference with normal construction activities**
- **SF9: Construction duration, will take extra time to be sorted, hence delay finishing project time.**
- **SF10: cost for managing CSW on site**
- **Answer in few words:**
- **1-How do you deal with the construction solid waste?**
- **3-working experience in Khartoum about .....years.**

4 Results and Analyses

The output from the questionnaires concluded that ;
a-minimum number of years for experience was 7 years,
b-70% of the total number distributed is fully answered and returned.
c- 10% thought no way csw can be managed, but answered anyway
d- Others just ignored.
From the total output 45responded, most of them complained that the keys are only focused on onsite sorting, rather than sorting. While 30% evaluated directly and agreed that it's time to make use of the csw.

Besides, most complains were about the difficulty to evaluate the factors they preferred Arabic rather than English for the questionnaire.
If the analyses of these factors could reflect the relation between the cswm as minimization of csw for a better environment through waste sort ability, then on-site sorting practice as a target would be an achievement, see flow chart 1,below. The figure shows that to manage csw through 3rs i.e., minimizing csw the only link is through waste sorting



Flow chart- framework of questionnaire factors affecting cswm, author2020

Flow chart1 Questionnaire factors affecting cswm, author 2020

Table 2, factors ranking

no.	SSF	rank
SF 8	Interference with normal construction activities	0.72
SF4	The role of management in minimizing the generation of csw	0.59
SF9	Construction duration	0.59
SF 3	waste sort ability	0.46
SF 2	development of Market for recycled materials	0.46
SF 5	site space	0.44
SF 7	Environmental considerations	0.43
SF 6	equipment required for sorting	0.42
SF 1	labour for on-site sorting	0.42
SF 10	cost for managing csw on site	0.41

4.1-Questionnaire Analyses

Then, these factors are evaluated according to their effect on csw sorting process by ranking from 1-5; score 1 is to the lowest level with low effect on the csw sorting, ascending to level 5 for the highest effect, and the scores in between rank medium.

Relative importance index analysis allows the identification of most of the important criteria based on participants' responses to questionnaires or interviews. Also, it is an appropriate tool to priorities indicators rated.

These data are analyzed by using the formula of relative index analysis method as supported by previous related

studies. Relative Importance Index (RII) is calculated for each of the indicators and ranked accordingly.

The RII derived to summarize the importance of each indicator:

Where,

$$RII = \Sigma W / (N * A)$$

W-is the weighting given to each factor by the respondents (ranging from 1 to 5),

A-is the highest weight (i.e. 10 in this case) and,

N-is the total number of respondents,45 in this case.

Where in this case there are three levels range of evaluation:

Low=1- 2.5, medium= >2.5 - 3.5, high= >3.5 – 5

Results of sorting factors by ssf and ranking effect were indicted in table below.

For example the first factor is calculated as follows;

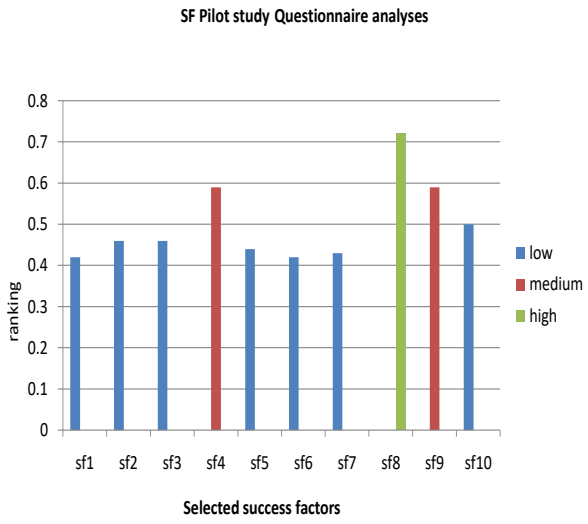
RII=4.3*3+3.1*5+108*37/45*5

RII=0.42

Table-2ranking in descending order, pilot study, author 2020

The analyses reflected which factors have stronger effect in relation to others as shown in graph 1.

Graph 1-ranking of sf for pilot study, author2020



Rearranging the factors from high value that affect sorting on site to the lowest, the ranking indicated that the three highest effects are caused by interference with normal construction activities, role of management in minimizing csw generation and construction duration. However, the highest SF rank point would be the interference with the normal construction, (SF8) which lead to the cause of delaying for construction duration, (SF9).These are the most important factors that would oppose the sorting of csw at source, not forgetting the extra cost for labour to do the sorting, will increase the cost directly so this explain why sorting on site not considered a priority.

Followed by;

- Better management, SF4 factor, got higher rank than waste sort ability, SF3 which means management for reducing csw was appreciated, but still on site sorting weakly approved, maybe if space ,SF5, is available which ranked as medium low category, the approval will raise.

-Development of official markets SF2 would be encouraged.

-Environmental considerations SF7 got a low rank which means, still people don't deal with csw as a polluter, hence more awareness needed.

-Equipment SF6, labour SF1, and cost of managing waste SF10, were the lowest which indicated that any costly procedure used for sorting is not preferred.

These results indicated that the respondent priority was to avoid extra cost and time loss by onsite sorting in construction projects, but if waste sort ability occurred, it will give products to the markets and balance the cost.

The two high ranked factors are linked in a framework as they indicate their contribution to csw management through waste sorting in the study Flow chart1.

The main idea for minimizing csw, and seek a way to allow sorting csw through the 3Rs process, and balanced cost with markets, in order to lead directly to a better environment.

5 Conclusions

The outcome of the pilot study has managed to identify some of the factors that strongly affect onsite sorting management, such as:

1- the idea of waste reduction is approved, but csw sorting onsite is not preferred,.

2-Respondents claim that waste management, will delay the construction process, and need extra cost for labors that make the sorting.

3- Markets for reusable building material are approved by respondents, but existing ones are not official.

4- low environmental considerations

As long as funding for management is considered costly, the improper waste management practices in the construction projects will continue. Achievements towards reducing environmental impacts and illegal dumping can be difficult.

6 Recommendations

The following are recommended:

-raising awareness is required to the importance of minimizing csw.

-Sorting approved to be necessary for managing csw, if onsite sorting not appreciated then off site sorting is recommended.

- when considering time and cost, csw should not be considered as an extra job.

7 FUTURE SCOPE

Management approach is to extend to, social performance, and economical aspect of csw to grantee better environment. Thus, it is becoming a necessity to approach minimizing the csw before transported to landfills, by sorting. Encouraging the material reuse and recycle through official markets. Since onsite sorting is not preferably applicable, further studies must introduce an organized system for offsite sorting.

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