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Hazard Evaluation of Lithium-ion Battery Used in Mobile Devices using SMUG model

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Abstract
Cell phones are electronic devices. Most cell phones use lithium ion battery for their operation. Batteries are made up of different chemical compositions including hazardous component. When battery is exposed to environment, it causes hazard. To mitigate the deleterious effects of lithium ion battery used in mobile devices, its hazardous effects must be measured first. This research is focused on finding different hazards caused by mobile battery. One of the methods to evaluate the hazard is by using seriousness, manageability, urgency, and growth (SMUG) model. This model uses four parameters; namely: seriousness, manageability, urgency and growth. These parameters are measured by the expertise in the field of battery. After designing SMUG model, hazard associated with lithium ion battery can be identified.

Keywords
Mobile – Lithium ion battery – SMUG – Hazard – Expert

1. Introduction

Battery, a charge storing device, is found in every electronic device. Battery is a device used to generate electrical energy. It powers hand phones, remote control, flash lights, hearing aids and helps cars to start easily [1]. Hazard means harmful effect to the environment, human health or property. Both renewable and non-renewable batteries are used in different electronics devices. An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices [2]. Rechargeable batteries come in all shapes and sizes. The most common types are Lithium Ion (Li-ion), Nickel Cadmium (NiCd), Nickel Metal Hydride (NiMH), Nickel Zinc (NiZn), and lead acid [3]. A type of lithium ion battery, a lithium cobalt oxide, is used in most of the mobile phone.

Rechargeable batteries contain numerous chemicals such as nickel, cadmium, and lead. If thrown in the trash, these chemicals can contaminate surface and groundwater supplies. Due to high energy density of lithium and lithium ion batteries, it is used in different industrial, military and consumer applications since 1990s [4]. A considerable research effort has been invested in developing inherently safer chemistries, and the development of more effective thermal management systems and protection devices.

Battery is considered as technology innovation and management model, which is illustrated in following figure.

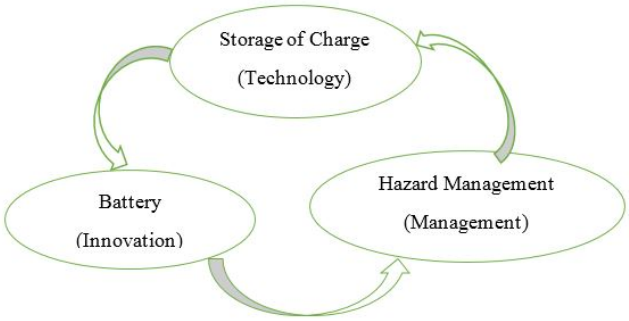

Figure 1: Battery as a Technology, Innovation and Management

According to different lithium compound, lithium ion battery are classified into six different category, namely Lithium Cobalt Oxide, Lithium Manganese Oxide,

Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt Oxide, Lithium Nickel Cobalt Aluminum Oxide and Lithium Titanate [5]. The Lithium Cobalt Oxide type of lithium ion battery is found in smart phone and Laptop devices due to its high capacity.

When lithium reacts with water, it produces lithium hydroxide and hydrogen gas. When lithium comes in contact with nitrogen gas present in air, it produces lithium nitride and produces lithium carbonate from reaction with carbon dioxide. Lithium oxide is formed when lithium reacts with oxygen. These compounds cause environmental and health impact, so to minimize this effect, the research on lithium ion battery is needed [6]. The analysis and evaluation of the hazard can be done with different approaches. The traditional approach is based on likelihood and consequences of hazard produced by any material. The modern approach, which involves more detail analysis is based on SMUG model. This model provides the measure of four different parameter namely seriousness, manageability, urgency and growth [7]. These parameter are further divided into sub parameter as in shown below figure.

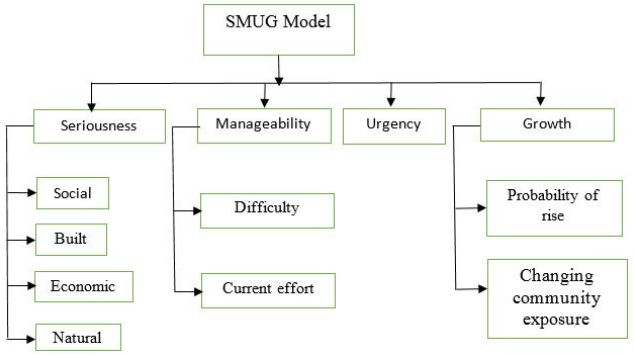

Figure 2: Parameter of SMUG model

2. Methodology

This research consists of mainly two parts, one is survey from mobile users and another is from experts in the field. This research is done by collection of data by surveying. This contain both quantitative and qualitative type of data collection. To analyze the collected data, graphical representation technique is used.

The overall methodology is as followed:

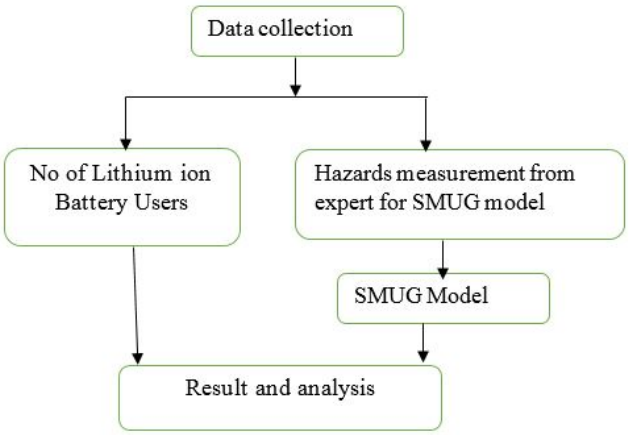

Figure 3: Methodology of Research

The first survey is done on people who live in Lalitpur sub metropolitan city to find the total lithium ion battery. And another survey for SMUG model is done with selected expertise in the field of battery. This collected data can be analyzed and presented in graphical representation.

3. Result and Discussion

The analysis part is done after collection of data. Here data is collected from two different level for different approach. First the data of mobile user in Lalitpur sub metropolitan city is collected by taking sample to find the total lithium ion battery used in mobile phone. 254 persons are selected for the questionnaire. And for the SMUG model part 8 experts are selected from different sector all relating to the field of battery. The collected data is analyzed in excel sheet and the data collected in survey are presented in graphical representation.

3.1 User survey analysis

The total data of 254 people were taken in the user level survey to. Assuming this sample size as a 100% the mobile user and total mobile battery are plotted in figure below. The total mobile battery is greater in number than total mobile user due to the fact that some of user around 30% are using extra battery or power bank for the mobile devices.

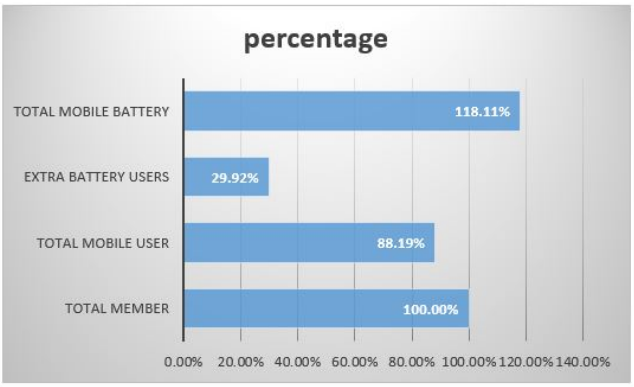

Figure 4: Data from mobile user in percentage

3.2 Data analysis for SMUG model

The parameter of SMUG model as seriousness, manageability, urgency and growth were collected form experts and after simple mathematical computation (summation and taking average) overall score was obtained. Each parameter of SMUG model have value of 1 to 5, considering 1 as very low and 5 as a high. The collected data is presented in graph below.

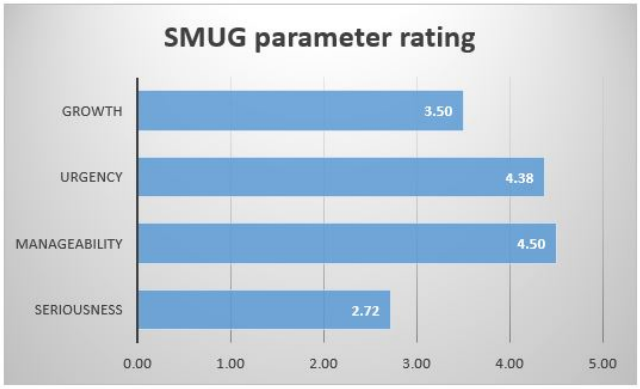

Figure 5: SMUG parameter rating

The manageability rating has a highest rating 4.5 out of 5. This high value indicates that it is hard to mitigate the hazard relating to lithium ion battery.

The same graph is presented in percentage form for easy analysis is as presented in graph below.

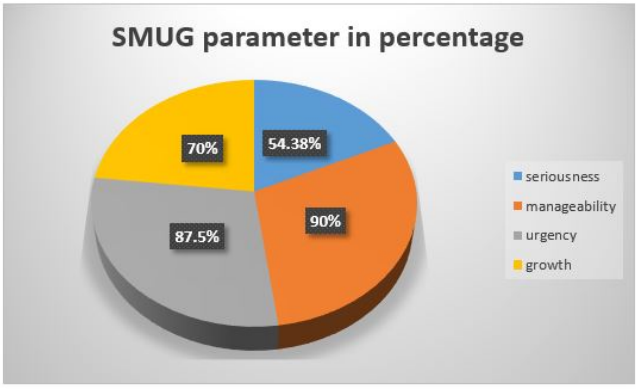

Figure 6: SMUG parameter in percentage

From the above graphical representation, it is clear that lithium ion battery, its management and urgency rating is high, which indicates that it is very urgent to manage the hazard cause by lithium ion battery. Current efforts regarding managing battery hazard is less in case of mobile battery.

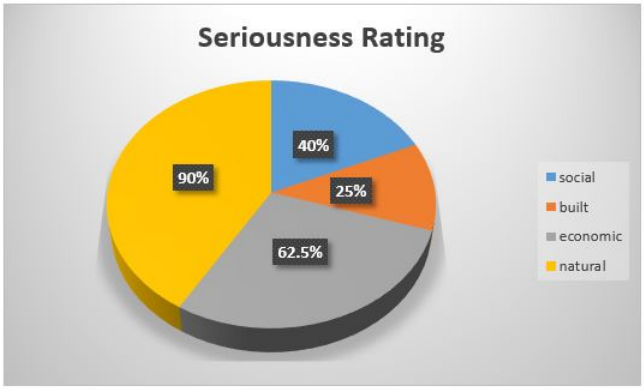

Figure 7: Seriousness rating

The seriousness rating is measured in four sub parameter namely social, built, economic and natural. From graphical representation presented above, mobile battery hazard is more serious to the natural sector and then economic and social and then to the building sector.

3.3 Discussion

From the research analysis, the data of mobile user and mobile battery is obtained. Some of the mobile users are taking extra battery for their mobile devices. As population increases, the number of mobile users also increases which results in increase in lithium ion battery.

The SMUG model indicates four different parameter seriousness, manageability, urgency and growth parameter. All these parameter are measured independently. The data are interpreted from different expert. The SMUG rating from different experts are varying in nature. But mostly these parameter rating vary in similar fashion, so it can provide good result.

4. Conclusion and Recommendation

The data from mobile users indicates that the total number of mobile batteries was greater than the total number of mobile devices. Hence, the hazard relating to mobile batteries cannot be neglected. From the SMUG model, the rating of each parameter (seriousness, manageability, urgency and growth) was obtained. Seriousness, manageability, urgency and growth parameters were found as 2.72, 4.5, 4.38 and 3.5 respectively. Each parameter indicates the hazard related with lithium ion battery.

This research provide the hazard associated with lithium ion battery. To mitigate such hazard, the disposal of solid wastes must be followed strictly and further research to minimize such hazard in technical way is necessary. Other researchers can also focus on recovery and recycle of Lithium ion battery.

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