6
Conclusion and Scope of Future Work

6.1 SUMMARY OF WORK

It is for the first time that traditional water storage devices and material processes for household construction in western Rajasthan have been investigated for presence of hidden engineering design and techniques. These devices and processes have sustained through centuries and have direct harmony with local environment and ecology. Rural construction and water storage is the subject area. A curious observation reveals aspects of solid waste management where soil is enabled by a carbonaceous material addition and used in daily household activities in certain communities. These modified soils can be generally termed as soil-carbonaceous matter immingle (SCMI). The processes and technologies ensured proper management and recycling of material, resource availability and local productivity. There is a decline in people and societies bearing this traditional knowledge. The decline is attributed to advent of modern construction practice, large earnings from other workspaces, no effective mobilization by the government to create interests in traditional artistic skill sets, new generation not willing to take up traditional skills and processes within the family and improvement in purchasing power of individuals. Two distinct engineering investigations and one technological application of these SCMI investigations can be easily observed from this dissertation as illustrated in Figure 6.1.

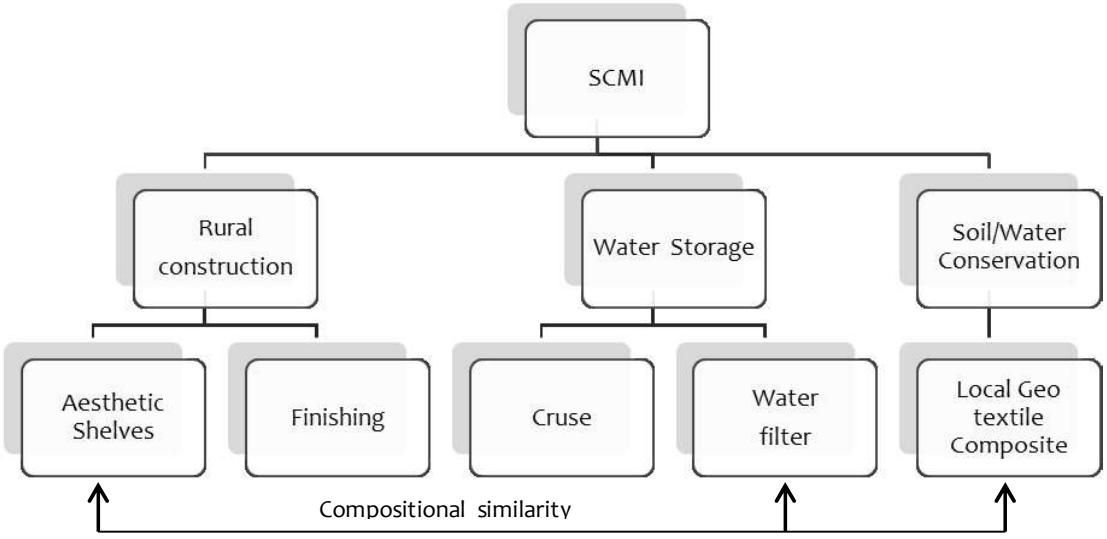

Figure 6.1: SCMI-based products and processes

From the discussions in the previous chapters, it is observed that soils with clayey nature are appended with carbonaceous matter for application in several traditional products and processes. Most of these mixes are heterogeneous. In Rajasthan, the soil-carbonaceous matter immingle (SCMI) finds its use in household construction, soil and water use management. A similitude in the compositional ratio of composites and ceramics thus manufactured from these immingle observed and is illustrated Figure 6.1.

Aesthetic shelves - Equal volume fraction of clayey soils and horse dung are used in the construction of traditional aesthetic shelves within households of *Santhi* community from this region. This material-based knowledge of people has been part of the traditional lifestyle of this community (Rajasthan's Thar Desert-based nomadic tribal community) for decades. This old-age technology is still being practiced. It had orally been passed on from one generation to the next generation. The development of flexural strength for such an immingle when saturated with water was found to improve with time [Kaurwar *et al*.,

2018]. The reason behind the application of the material and devices are supposed to be the part of cultural hereditary rather than technological aspect.

Cruse-Traditionally cruse sustainability was thought to be due to its off-white coloration and influenced by culture [Roux, 2015]. Local salty soils of this region abundant in Mg and Ca compounds help in the production of sustainable cruse covered with amorphous off-white Mg and Ca oxides. From an economic point of view, the availability of materials is always considered an important criterion for material selection. Cruse used in western Rajasthan for water storage was found to have comparatively better water-cooling characteristics than imported cruse from neighboring state Gujarat.

G-Filter-Apart from the cruse, the process for manufacturing the local ceramic water filter named the G-filter was also developed during this study. Here, the immingle of the equal volume fraction of clayey soils and carbonaceous matter (sawdust) is used as raw material. For this purpose, the immingle is mixed with water to manufacture a green composite. Dried frustum shaped filter green composite is then fired in an open-hearth furnace. The firing process temperature distribution is strictly similar to that of the local traditional baking process for manufacturing clay flower vases in western Rajasthan. Therefore, local household manufacturing and baking make this new approach distinct from the "Potters for Peace" factory-based approach. This is the first decentralized approach to the manufacture of low-cost ceramic water filters designed to preserve the livelihood of rural artisanal traditional potter [Gupta *et al*., 2018]. The G-filter filtrate satisfies the international standards for drinking water quality [Gupta *et al*., 2018, Soyam *et al*., 2016]. Based on gravity filtration method, the technology does not consume electricity and does not waste water during the filtration process. Presently, it is produced by potters in villages of Sar, Salawas and Banad in Jodhpur Rajasthan and Tindivanum in Tamil Nadu respectively.

6.2 CONCLUSIONS FROM THE THESIS

The importance of equal volume fractions of soil and organic material composition for construction in *Sansi* community is enumerated. Explanations for such an importance to this specific material as well as composition are elaborated using strength analysis along with micro structural variations. It is observed that the presence of biological calcium in carbonate form contributed immensely in the strength development of the composites manufactured from this composition. Distinct volume fractions of Equus dung showcased variability in strength properties with time. Surface roughness of such materials can be used to elaborate on these strength properties such as fracture toughness. Resistance to flexure is time dependent and varies for different composites with variable compositions. A new quotient response multi-parameter model for flexural strength as a function of time is developed. Composites manufactured with equal volume fraction attained the maximum flexural strength. The results provide scientific explanations for the method of making bio-composites for construction. Further, it provides scientific basis and explanations for an indigenous knowledge system for rural India. The other major aspect is the affordability of the materials and sustainability of such structures at a specific ecological area. This also implies at finding local waste yet cellulosic materials for building construction which when adopted will effectively reduce material transportation cost and manufacturing energy cost compared to conventional cement-based structures [Morel *et al*., 2001].

Use of off-white ceramic water storage devices rather than red ones for cooling water is observed at local households in Jodhpur, Rajasthan. These off-white pots are better compressive strength compared to red pots. The cruse takes 2 hours to provide palmary cooling of drinking water when stored. Off-white pots can be baked at lower temperatures than red pots thus saving fuel. These may be some of the technological characteristics which may be reasons for promoting off-white pots usage in traditional practices across western Rajasthan. Tensile strength and cooling behavior will be explored in future. The production techniques elaborated here in the literature are widely used by the potters of India, but there was no scientific explanation on the fact that off-white pots are prominently used in western Rajasthan than red pots. This chapter also predicts the structural strength of cruse material derived from a specific height as a function of same for the first time.

Household mode of manufacturing indigenous clay ceramic water filters is discussed. The production management in household manufacturing mode is also investigated. The manufacturing practices have close parallels with the best management practices such as modern quality control framework at workplaces. A new octahedral framework for managing production of these filters is

envisaged. These filters green ware is sintered using the flower vase baking technique followed by potters of Western Rajasthan. The filtration rate through these clay ceramic filters is ambient temperature dependent. The microbial treatment efficacy of such filters is at par with clay ceramic water filter produced in factories elsewhere. The implication is that potter households dispersed at a different location in western Rajasthan and across India can locally and individually choose to manufacture G-filters and distribute to their surroundings. This reduces the cost of transporting water filters to remote locations in rural India.

6.3 SCOPE FOR FUTURE WORK

The scope of future work from this thesis is multi-disciplinary and can touch upon the following aspects: -

- There is a need to review on rural or community-based housing and their decaying traditional skill set to sustain the knowledge on benefits of local materials.
- The thesis also promulgates the requirement of Social, Technological, Economic, Environmental, Political, Legal and Ethical (STEEPLE) management framework which is required to revive the sustenance of rural technologies which are obsolete and archaic [More *et al*., 2015].
- There is need to develop new framework on construction to integrate the use of traditional methodology with modern construction techniques to promote the use of local materials and indigenous knowledge.
- Adsorption kinetics of biologically available calcium carbonate and cellulose for matrix reinforcement should be studied.
- Thermodynamic analysis behind evaporation of water from the external surface of the cruse is to be analysed.
- The rural community skills in artistic areas other than pottery should also be investigated.
- G-filter should be tested for removal of microbial contaminants other than E. Coli.
- The scaling of the G-filter manufacturing and its industrial propagation needs to be explored.
- Study relating to the acceptability of G-filter for water filtration should be carried out.
- Randomized trials for the study on the efficacy of the G-filter need to be carried out in various parts of India with microbial contaminated low-quality drinking water. This will help to understand the reliability of such filters on the field.

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