Abstract

Frustum shaped ceramic water filter manufacturing technology has been introduced in different parts of India, scilicet Jodhpur district in Western Rajasthan, Tindivanum and Thiruvallur in Tamil Nadu and Samastipur in Bihar. The dissemination of the manufacturing technology was carried out among traditional potter families residing in these rural locations. The purifying receptacle of this water filter (named G Filter locally) in Western Rajasthan is made of low-cost raw materials - clay and sawdust taken in equal volume fractions. United Nations and NGOs such as Potters for Peace, (Nicaragua) Pure Home Water Filters (Ghana), RDIC Cambodia, Potters Without Borders etc. promote such low cost point of use gravity-based ceramic water purifiers across the globe to societies affected by water contamination or water scarcity due to natural calamities, economic scenarios etc.

More than a score of dissertations and graduate thesis from around the globe during the last two decades exemplify the importance of ceramic water filtration through similar frustum shaped low-cost water filters. Gravity-based filtration theory, microbial contamination removal, organic and inorganic contaminant removal, porous media flow theory, strength of brittle clay ceramics, public health behavior, clay-based manufacturing, wear, surface physics, transport phenomena, clay science, wood technology, material characterization, production, environmental science, marketing, rural development, customer satisfaction, household water treatment systems and socio-economic related to these filters are the research areas which can be cited while performing this work.

Firstly, the thesis is encouraged views of traditional potters of India. G Filter was introduced using a traditional blended manufacturing approach with mechanized forming at the different location. Traditionally, potters decode the efficacy of the clay artifacts by visual appearance and touch. This would mean that surfaces may hold answers to the strength and functionality of the ceramics manufactured. Indirectly ceramic surface characterization in terms of its roughness, pore, pore density, porosity will affect the strength. Compressive strength decreases polynomially with increasing surface roughness of clay-organic fraction ceramics (porous clay ceramics). The degree of the surface roughness increased proportionally with pore density. Fracture toughness of these materials decreased in a linear order with the increase in surface roughness. Furthermore, the fracture toughness also followed linear transformation with the sawdust used as a raw material while manufacturing the clay ceramics.

Composition characterization of fired clay ceramics showed the presence of fluxing compounds which contributed to their densification. The clay ceramics with equal volume fraction of clay and organic filler (50O) were characterized by the highest frequency of pores oriented orthogonal to the surface. This result affirms the feasibility of use of such clay ceramics for separation processes. The ceramic showcased more than 2 log reduction value while filtering E. Coli contaminated water.

Secondly, traditional potters from Bihar questioned the ability of the water filters to separate arsenic from their household groundwater supplies. This diverted attention to the search for local low-cost methods to separate arsenic in drinking water using distinct material modifications to the fired clay ceramics (50O). There are numerous decades of research on Fe and its reaction with arsenic in water to form large complexes which can be separated using adsorption and filtration methods. Bihar is home for India's iron production and use. Hence locally available Fe fines could solve the local arsenic contamination of groundwater in the region. The clay ceramic (50O) was modified by limited volume addition of Fe fines to the clay and organic material mixtures to form new Fe additive based ceramics (FCC). FCC ceramics when tested for arsenic adsorption, displayed high arsenic removal efficiency of 99% for a contact period of 90 mins. The Freundlich and Langmuir isotherm models well with the equilibrium

adsorption data. The addition of ferrous waste enhanced arsenic removal efficiency of clay ceramics between 3 pH to 7 pH. The 99% E.coli removal was found in FCC based ceramics. The mechanical strength of the clay ceramics was found to be nearly doubled with the incorporation of ferrous material.

Finally, the thesis is set in rural parts of Western Rajasthan dotted with abundant clayey soil and limestone mining locations. There are several studies where calcium based salt solutions treat arsenic-contaminated waters. The clay ceramics (CC or 50 O) was now modified by adding limited volumetric quantities of marble to the clay and organic material mixture to form new marble based ceramics (MCC). The addition of marble enhanced the arsenic removal efficiency of porous clay ceramics (CC). The MCC followed Freundlich adsorption model. The antibacterial property of marble removed microbes from the effluent. This proposed a low-cost alternative for enhancing microbial removal efficacy of ceramic filters. Marble addition greatly enhanced compressive strength and fracture toughness of the clay ceramics.

The implication of the study is on the design and development of low-cost ceramics for use in household water treatment. Moreover, the study indicates possible scale-up of G filter for treating specific contaminants. The new material developed presents a low cost option, easy manufacture and can be implemented within a constructed wetland system where targeted removal of specific contaminants is required from large volumes of surface or groundwater.