

a great need to discover bacterial resources for alginate production with higher viscosity, which may be exploited with little capital cost. Production of alginate depends on the demand from various industries, and the viscosity of the alginate production can be enhanced, for example, by using recombinant strains of *Azotobacter*, obtained by genetic manipulation [9].

2.2 Alginate: Production

Seaweeds are the major source for producing value-added polysaccharides and industrial by-products globally. Alginates are one of the chief products extracted from seaweeds, mainly brown algae. These polysaccharides constitute the structural composition of the cell walls and the intercellular matrix in seaweeds.

The ratio M/G varies with the source of alginates, but its physical properties, for similar M/G ratio, are almost the same even when extracted from different biosources. Alginates are most often used in food processing as a stabilizer, viscosity agent, and gelling agent, with annual industrial requirements of alginates reaching ~30,000 metric tons [10]. Alginates form 40% of the dry matter of the commercially harvested species of seaweeds, such as *Laminaria* spp. and *Macrocystis* spp. [11]. Recently, this polysaccharide has been used for wide range of pharmaceutical and biological products, as in wound dressings [12]. Prior to 1975, commercial alginate production was based on seaweeds, where they were treated with alkali solution followed by filtration. The alginates were precipitated with chloride salts of sodium/calcium cations, so that the alginate salts can be converted to alginic acid, on acidifying with dilute HCl. On purification, the obtained alginic acid gave water-soluble sodium alginates [13]. During the late 1980s, two genera of bacteria, the nonpathogenic *Pseudomonas* and *Azotobacter*, were identified to be major producers of alginate and alginic acids. In nature, microbes produce alginates through different metabolic processes with various material functions. *Pseudomonas aeruginosa* produces alginates that constitute the thick highly structured biofilm, characteristic of the species [9], whereas *Azotobacter* produces rigid alginate, essential for the formation of water-conserving cysts [14] resistant to desiccation and stress.

2.2.1 Screening of Alginate-Producing Microbes

Alginates are hydrocolloids derived from seaweed that interact with water to form colloid systems, like a gel or solubilized particles. Alginates are extracted in disparate ways depending on the application, but the most