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Soil Test Report of Kolabari and Sundortola, Chila, Mongla, Bagerhat

Test Ref. No.: **ST-10036**

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Executive Summary

The Mongla Port Authority is dredging Pashur River and dumping the dredged material in hundreds of acres of cropland in Khulna. The cultivators in the area reported that they grow three crops every year in that area. Farmers, local people, and civil society associations oppose the Port Authority's "sand dumping" because large scale dredged material dumping in the area will disrupt agricultural livelihoods and lead to the displacement of local communities. The Mongla Port Authority has threatened to press charges against farmers who oppose the Port Authority's dredging plans. The Port Authority claimed that appropriate steps were followed in determining the area for dumping and communities were compensated. The Port Authority also claimed that "some two-crop producing low land will be more cultivable for earth filling."[1] Determining the quality of dredged material has become crucial under current debates over the Port Authority's decision to continue its dumping plans.

The objective of this report is to determine whether the dredged material ("soil") is appropriate for crop cultivation. In this report, we collected soil samples from Kolabari and Sundortola, Chila, Mongla, Bagerhat where the Mongla Port Authority has dumped dredged soil. We used standard soil collection and testing processes to conduct a chemical analysis of the soil samples. Our results show that the collected soil media is not suitable in its current state for paddy or any other crop cultivation. The findings of this report imply that more tests need to conducted across all dumping sites before any dredged soil is declared cultivable. As our tested soil media samples are not suitable for cultivation (particularly due to its high salinity), intensive management and expensive inputs will be required to make the soil cultivable for the common crops in Bangladesh in areas impacted by the Mongla Port Authority's sand dumping.

[1] New Age. (2022, August 25). *Many feared to be homeless for sand dumping by Mongla Port*. New Age | The Most Popular Outspoken English Daily in Bangladesh. Retrieved September 23, 2022, from https://www.newagebd.net/article/179306/many-feared-to-be-homeless-for-sand-dumping-by-mongla-port

Introduction

Bangladesh is situated within 20”25’ to 26”38’ N latitudinal and 8801 to 92”41’ E longitudinal ranges having a total land area of about 144,000 km2, including 8,300 km” water bodies. A net cropped area of 91,300 km” occupies more than 60% of the total land mass. The area under paddy cultivation is about 80% of the cropped area. The climate of Bangladesh is tropical to subtropical monsoon, with most rainfall occurring between June and September. Mean annual rainfall is 2,200 mm, varying from 1,250mm in the west to 5,000 mm in the northeast. Mean annual temperature is 26 “C while mean monthly temperature varies from 18 “C in January to 30 “C during April and May.

There are three cropping seasons in Bangladesh: early kharif (April to June), late kharif (July to September), and rabi (October to March). The early kharif season is characterized by the highest temperature and evaporation with 20% of the annual rainfall occurring in this season. Main crops are aus rice, jute, and early summer vegetables. In the late kharif season, 80% of the total rainfall occurs. Flooding is very common, and one-third of the land remains under water. Main crops are aman rice and summer vegetables. The rabi is a dry and cool season with almost no rain. Main crops are boro rice, wheat, maize, pulses, oilseeds, groundnut, spices, and a wide variety of winter vegetables.

The soils of Bangladesh have been formed from different kinds of parent materials and spread over three major physiographic units: (i) Northern and eastern hills of Tertiary formations, covering 12% of the total area; (ii) Pleistocene terraces of the Madhupur and Barind tracts, covering 8% of the total area; and (iii) Recent floodplains. Recent floodplains mainly comprise alluvial sediments of the Ganges, Brahmaputra, and Meghna river systems, occupying 80% of the country and can be divided into Piedmont alluvial plains, meander floodplains, basin areas, estuarine floodplains, tidal floodplains, and sandy beaches.

Agriculture is the mainstay of the economy of Bangladesh. It contributes to over 50% of the gross domestic product and provides employment for 74% of the labor force. However, the present agricultural production is not sufficient for the 160 million population of the country which is increasing at the rate of about 1.78% annually. The yield of almost all crops is very low in Bangladesh in respect with some other developed countries. This is due to a number of reasons in which soil is a dominating factor.

The fertility status of Bangladesh soils has been worsening day by day. Most research papers on fertility status are limited in distribution and unavailable to scientists even within the country. In the report, we collected soil samples from Kolabari and Sundortola, Chila, Mongla, Bagerhat. We studied the present fertility status of the surface layer of both of those places after Soil from the dredging of the Pashur river was layered on those places. We will also assess the soil's characteristics and its effect on agriculture in those areas with the dredging soil.

Background

Soil is a vital part of the natural environment. It is just as important as plants, animals, rocks, landforms, lochs and rivers. It influences the distribution of plant species and provides a habitat for a wide range of organisms. It controls the flow of water and chemical substances between the atmosphere and the earth and acts as a source and store for gases (like oxygen and carbon dioxide) in the atmosphere. Soil is one of the most valuable natural resources available to us. It is very important for sustenance of life on the earth. The top soil which is suitable for plant growth is eroded due to human activities like construction of Thermal power plant, buildings, roads and expansions on the other hand the soil layers are contaminated deliberately due to Industrial pollution. The soils and its properties are affected to a great extent. The quality of soil is an function of its physical and chemical characteristics. Here is discussion about the importance of different chemical characteristics of soil and their impact of crop production.

Organic Matter

Organic matter is the storehouse of all the plant nutrients in the soil. It is the major source of two important mineral elements of P and S, and essentially the sole source of N. It is equally important in improving soil structural conditions, water and nutrient holding capacity, and microbial activities for successful cultivation. In general, the organic matter content of Bangladesh soils is low. Almost 90% soils of Bangladesh contained 0.5- 1.0% organic matter. It has been reported that addition of organic residues increased the organic matter content to the level of 1.1 to 1.3% from the initial level of 0.7% in the Shallow redbrown terrace soil by the annual application of 2.0 Mg/ha of air-dry rice straw, 7.5 Mg/ha of fresh ipilipil leaves, 25 Mg/ha of compost, or 25 Mg/ha of fresh cowdung under the ricewheat cropping rotation. Due to rapid decomposition rate, the organic matter content did not increase more, but the annual addition of organic residues increased the yield of both crops. Among the different organic residues, compost made of rice straw and cowdung was found to be most effective.

The organic matter status of Bangladesh soils is not only poor but also becoming worse day by day. It is also reported the 9 to 46% depletion of soil organic matter in different regions of Bangladesh over a period of 20 years from 1970 to 1990. There are several reasons behind the low organic matter content of Bangladesh soils. The main reason is lack of organic recycling through addition of crop residues, animal waste, and other organic manures.

Due to the fuel scarcity, plant residues including shoots and even roots, and cowdung have been used as fuel. According to Bhuiya (1987), as a tropical monsoon climatic country plants in general grow luxuriantly in the summer season, but due to the high temperature and rainfall the organic matter added to soil in the form of biomass is decomposed rapidly. It is also reported that due to the intensive cultivation, the soils were being disturbed vigorously through tillage operation like plowing, puddling, laddering and so on, leading to enhancement of decomposition of organic matter. Use of urea fertilizer, which is presently a main nitrogenous fertilizer in Bangladesh, may enhance microbial activities resulting in the decomposition of organic matter, as revealed from an incubation study in the laboratory. Low-lying areas of most floodplains have a good reserve of organic matter, higher than that in high land or medium-high land. These soils remain under water for a considerable period of time of a year. So, little decomposition of organic matter can occur. Moreover, a large number of aquatic weeds grow which add organic matter to these soils.

Arsenic

Arsenic (As) as a toxic metalloid is mostly present in agricultural soils but have damaging effect on cells and tissues of humans when exposed at high concentration. The concentration of arsenic in soils varies with geographical regions, but the average total concentration of arsenic in soil is 5 mg/kg. The common associates of arsenic are hydroxides of aluminium (Al), manganese (Mn), sulphides, oxides and iron (Fe).

Arsenic (As) occurs mainly in its inorganic forms (arsenate AsV and arsenite AsIII) which are more toxic than its organic forms. The reductive dissolution of soil mineral hydroxides by microbes and organic matter is regarded as the main mechanism releasing arsenic into the aquifer. The use of arsenic contaminated groundwater for irrigation of agricultural fields facilitates the entry of arsenic in the food chain through consumption of contaminated food products affecting a large number of people mainly in the South Asia and other parts of the world. The long-term use of arsenic contaminated groundwater for irrigation of agricultural soils may lead to excessive accumulation of arsenic in the soil which, in turn, may exert land degradation in terms of loss of yield i.e. decline in crop production and disease like 'straighthead disease' with empty panicle in rice. A good correlation between arsenic uptake in plants/crops and total arsenic content in soils is not always found. It is revealed that soil total arsenic content is not likely a good predictor of arsenic uptake and toxicity under different soil types and micro-climatic conditions. It is the bioavailable fraction of total arsenic in specific soil condition, which is potentially causing a threat to the crops/plants.

pH

Soil pH is the value measure of acidity and alkalinity it possesses. Soil pH value is considered as one of the most vital factors which may determine the yield of the crops. Soil pH can regulate and control many chemical and biochemical reactions within the soil. It plays a major role in making the plant nutrients available involving in the chemical reactions of nutrients and pH can also have effect on chemical forms of the nutrients.

Soil pH have a special function in maintaining the population of soil micro flora and fauna. These processes of soil pH with plant nutrient have got significant influence on the crop productivity.

Agricultural soil pH optimum value falls in range of 5.5 to 7. Many of the agricultural crops grow well in the optimum pH range of soil but some crops have an ability to grow outside the optimum value may be due to the adaptability but some plants cannot tolerate the acidity.

The acidity nature of the soil can dissolve the soil minerals and these metallic ions may lead to toxicity to the plants. In normal cases the aluminium metal ions are toxic in the acidic soils. High levels of manganese and iron may inhibit the normal growth of the crop plants. Many applied nutrients like Phosphorous, Calcium, Magnesium and molybdenum nutrients are less available to the plants in acidic soils.

In case of the alkaline soils the solubility of minerals is reduced so that plant may exhibit the deficiency symptoms. The deficiency in iron, manganese, zinc, copper and boron are observed more in high pH soils. In high pH alkaline soils, the major nutrient Phosphorus is also less available. High levels of calcium deposits will get accumulated and may inhibit the uptake of potassium and magnesium nutrients.

Plant roots absorb the molecular forms of soil nutrients such as nitrogen, potassium, phosphorus, magnesium, and boron. These nutrients and others which support plant life are most easily absorbed by plant roots when the soil pH is near neutral (7.0). Most plants thrive in a pH range anywhere between 6.0 and 7.5 (the acidity-alkalinity scale ranges from 0 to 14; the low end of the scale indicates acid and the high end is alkaline). Nutrient shortages tend to occur when the soil is extremely acid or alkaline. Values of pH 7 indicate a neutral soil; a value above pH 7 is alkaline and below pH 7 is acid. Most soils are within a range of highly acidic pH 4 to alkaline a pH 7.5 to 8. Soils that are more alkaline are known as “sweet” and those more acid are called “sour.” Vegetables and other plants grow best when the soil pH is optimal for the plants being grown. It is important to match a plant to the soil pH or to adjust the soil pH to a plant’s needs.

Total Nitrogen

Nitrogen (N) plays an important role in crop plants. It is involved in various critical processes, such as growth, leaf area-expansion and biomass-yield production. Various plant molecules such as amino acids, chlorophyll, nucleic acids, ATP and phyto-hormones, that contains nitrogen as a structural part, are necessary to complete the biological processes, involving carbon and nitrogen metabolisms, photosynthesis and protein production. Insufficient amount of N available to plants can hinder the growth and development. Nitrogen can also improve root growth, increase the volume, area, diameter, total and main root length, dry mass and subsequently increase nutrient uptake and enhance nutrient balance and dry mass production.

Nitrogen is the main limiting nutrient after carbon, hydrogen and oxygen for photosynthetic process, phyto-hormonal, proteomic changes and growth-development of plants to complete its lifecycle. Excessive and inefficient use of N fertilizer results in enhanced crop production costs and atmospheric pollution. Atmospheric nitrogen (71%) in the molecular form is not available for the plants. For world’s sustainable food production and atmospheric benefits, there is an urgent need to up-grade nitrogen use efficiency in agricultural farming system. The nitrogen use efficiency is the product of nitrogen uptake efficiency and nitrogen utilization efficiency, it varies from 30.2 to 53.2%. Nitrogen losses are too high, due to excess amount, low plant population, poor application methods etc., which can go up to 70% of total available nitrogen. These losses can be minimized up to 15–30% by adopting improved agronomic approaches such as optimal dosage of nitrogen, application of N by using canopy sensors, maintaining plant population, drip fertigation and legume based intercropping. A few transgenic studies have shown improvement in nitrogen uptake and even increase in biomass.

Nitrate reductase, nitrite reductase, glutamine synthetase, glutamine oxoglutarate aminotransferase and asparagine synthetase enzyme have a great role in nitrogen metabolism.

Nitrogen (N) plays an important role in crop plants. It is involved in various critical processes, such as growth, leaf area-expansion and biomass-yield production. Various plant molecules such as amino acids, chlorophyll, nucleic acids, ATP and phyto-hormones, that contains nitrogen as a structural part, are necessary to complete the biological processes, involving carbon and nitrogen metabolisms, photosynthesis and protein production. Insufficient amount of N available to plants can hinder the growth and development. Nitrogen can also improve root growth, increase the volume, area, diameter, total and main root length, dry mass and subsequently increase nutrient uptake and enhance nutrient balance and dry mass production.

Application of nitrogen increases greenness of plants, CO2 assimilation rate, crop quality-yield and improve resistance to environmental stresses such as limited water availability and saline soil conditions. It was found that nitrogen application more important than the other major essential fertilizers/nutrient for successful crop production. Consequently, N requirement is the most central feature for plant production. Slow development of plant and early leaf senescence due to deficient N can cause decreased both crop production and quality.

Salinity

Salinity becomes a problem when enough salts accumulate in the root zone to negatively affect plant growth. Excess salts in the root zone hinder plant roots from withdrawing water from surrounding soil. This lowers the amount of water available to the plant, regardless of the amount of water actually in the root zone. For example, when plant growth is compared in two identical soils with the same moisture levels, one soil receiving salty water and the other receiving salt-free water, plants are able to use more water from the soil receiving salt-free water. Although the water is not held tighter to the soil in saline environments, the presence of salt in the water causes plants to exert more energy extracting water from the soil. The main point is that excess salinity in soil water can decrease plant available water and cause plant stress. Soil water salinity is dependent on soil type, climate, water use and irrigation routines. For example, immediately after the soil is irrigated, plant available water is at its highest and soil water salinity is at its lowest. However, as plants use soil water, the remaining water is held tighter to the soil and becomes progressively more difficult for plants to obtain. As the water is taken up by plants through transpiration or lost to the atmosphere by evaporation, soil water salinity increases because salts become more concentrated in the remaining soil water.

Soil water salinity can affect soil physical properties by causing fine particles to bind together into aggregates. This process is known as flocculation and is beneficial in terms of soil aeration, root penetration, and root growth. Although increasing soil solution salinity has a positive effect on soil aggregation and stabilization, at high levels salinity can have negative and potentially lethal effects on plants. As a result, salinity cannot be increased to maintain soil structure without considering potential impacts on plant health.

Agricultural crops exhibit a spectrum of responses under salt stress. Salinity not only decreases the agricultural production of most crops, but also, effects soil physicochemical properties, and ecological balance of the area. The impacts of salinity include—low agricultural productivity, low economic returns and soil erosions. Salinity effects are the results of complex interactions among morphological, physiological, and biochemical processes including seed germination, plant growth, and water and nutrient uptake. Salinity affects almost all aspects of plant development including: germination, vegetative growth and reproductive development. Soil salinity imposes ion toxicity, osmotic stress, nutrient (N, Ca, K, P, Fe, Zn) deficiency and oxidative stress on plants, and thus limits water uptake from soil. Soil salinity significantly reduces plant phosphorus (P) uptake because phosphate ions precipitate with Ca ions. Some elements, such as sodium, chlorine, and boron, have specific toxic effects on plants. Excessive accumulation of sodium in cell walls can rapidly lead to osmotic stress and cell death. Plants sensitive to these elements may be affected at relatively low salt concentrations if the soil contains enough of the toxic element. Because many salts are also plant nutrients, high salt levels in the soil can upset the nutrient balance in the plant or interfere with the uptake of some nutrients.

Salinity also affects photosynthesis mainly through a reduction in leaf area, chlorophyll content and stomatal conductance, and to a lesser extent through a decrease in photosystem II efficiency. Salinity adversely affects reproductive development by inhabiting microsporogenesis and stamen filament elongation, enhancing programed cell death in some tissue types, ovule abortion and senescence of fertilized embryos. The saline growth medium causes many adverse effects on plant growth, due to a low osmotic potential of soil solution (osmotic stress), specific ion effects (salt stress), nutritional imbalances, or a combination of these factors. All these factors cause adverse effects on plant growth and development at physiological and biochemical levels, and at the molecular level. In order to assess the tolerance of plants to salinity stress, growth or survival of the plant is measured because it integrates the up- or down-regulation of many physiological mechanisms occurring within the plant. Osmotic balance is essential for plants growing in saline medium. Failure of this balance results in loss of turgidity, cell dehydration and ultimately, death of cells. On the other hand, adverse effects of salinity on plant growth may also result from impairment of the supply of photosynthetic assimilates or hormones to the growing tissues (Ashraf, 2004). Ion toxicity is the result of replacement of K+ by Na+ in biochemical reactions, and Na+ and Cl− induced conformational changes in proteins. For several enzymes, K+ acts as cofactor and cannot be substituted by Na+. High K+ concentration is also required for binding tRNA to ribosomes and thus protein synthesis. Ion toxicity and osmotic stress cause metabolic imbalance, which in turn leads to oxidative stress. The adverse effects of salinity on plant development are more profound during the reproductive phase. Hence, the adverse effects of salinity may be attributed to the salt-stress effect on the cell cycle and differentiation. Salinity arrests the cell cycle transiently by reducing the expression and activity of cyclins and cyclin-dependent kinases that results in fewer cells in the meristem, thus limiting growth. The activity of cyclin-dependent kinase is diminished also by post-translational inhibition during salt stress. Recent reports also show that salinity adversely affects plant growth and development, hindering seed germination, seedling growth, enzyme activity.

Phosphorus

Phosphorus is one of the major plant nutrients in the soil. It is a constituent of plant cells, essential for cell division and development of the growing tip of the plant. For this reason it is vital for seedlings and young plants. Without phosphorus, plant growth is retarded. Plants have stunted roots, and are stunted and spindly. Deficiency symptoms also include dull greyish-green leaves and red pigment in leaf bases and dying leaves. Phosphorus deficiency is difficult to diagnose, and by the time it is recognised it may be too late to do anything. If plants are starved of phosphorus as seedlings they may not recover when phosphorus is applied later.

Phosphorus is a component of the complex nucleic acid structure of plants, which regulates protein synthesis. Phosphorus is, therefore, important in cell division and development of new tissue. Phosphorus is also associated with complex energy transformations in the plant. Adding phosphorus to soil low in available phosphorus promotes root growth and winter hardiness, stimulates tillering, and often hastens maturity. Plants deficient in phosphorus are stunted in growth and often have an abnormal dark-green color. Sugars can accumulate and cause anthocyanin pigments to develop, producing a reddish-purple color. This can sometimes be seen in early spring on low phosphorus sites. These symptoms usually only persist on extremely low phosphorus soils. It should be noted that these are severe phosphorus deficiency symptoms and crops may respond well to phosphorus fertilization without showing characteristic deficiencies. In addition, the reddish-purple color does not always indicate phosphorus deficiency but may be a normal plant characteristic. Red coloring may be induced by other factors such as insect damage which causes interruption of sugar transport to the grain. Phosphorus deficiencies may even look somewhat similar to nitrogen deficiency when plants are small. Yellow, unthrifty plants may be phosphorus deficient due to cold temperatures which affect root extension and soil phosphorus uptake. When the soil warms, deficiencies may disappear. In wheat, a very typical deficiency symptom is delayed maturity, which is often observed on eroded hillsides where soil phosphorus is low. Phosphorus is often recommended as a row-applied starter fertilizer for increasing early growth. University of Nebraska starter fertilizer studies conducted in the 1980s showed early growth response to phosphorus in less than 40 percent of the test fields. Starter applications may increase early growth even if phosphorus does not increase grain yield. Producers need to carefully evaluate cosmetic effects of fertilizer application versus increased profits from yield increases.

Sodium

Soil provides sodium in plants. There's a natural accumulation of sodium in soil from fertilizers, pesticides, run off from shallow salt-laden waters, and the breakdown of minerals which releases salt. Excess sodium in soil gets taken up by plant roots and can cause serious problem.

Sodium (Na^+) is an abundant element which makes up around 3% of the earth's crust. Furthermore, it is found in almost all surface and subterranean water bodies and of course is plentiful in seas and oceans where it can reach over 5%. It is not surprising then that most plants will get in contact with Na^+ at some stage during their life cycle although the encountered levels may vary greatly. At the extreme end, terrestrial and aquatic plants can be exposed to levels of salinity (NaCl) that are two or three times higher than that of seawater (~540mM) but very few species are capable of withstanding such an onslaught. Less extreme, and more widespread, are low and intermediate levels of salinization which occur all over the world.

Salinization can arise through natural causes, such as the local geology or proximity to coastal areas, or be man-made, for example, through the use of irrigation water that contains high concentrations of salts. Although mostly Na+ and Cl–, saline soils often contain high concentrations of other inorganics such as calcium (Ca2+), sulphate (graphic), and bicarbonate (graphic). On the other end of the spectrum, areas with high levels of precipitation may be almost devoid of Na+ since it is relatively mobile in the soil. Consequently, plants living in these regions may only encounter trace levels of Na+. For almost all terrestrial plants, Na+ is not essential for either growth and development or for reproduction.

Potassium

Potassium (K), along with nitrogen and phosphorus, is one of the three essential plant macronutrients, and is taken up by crops from soils in relatively large amounts. Potassium increases yields and improves the quality of agricultural produce. Potassium also enhances the ability of plants to resist diseases, insect attacks, cold and drought stresses and other adverse conditions. It helps in the development of a strong and healthy root system and increases the efficiency of the uptake and use of nitrogen and other nutrients. In addition, potassium has an important role in livestock nutrition. The importance of potassium stems from its multiple roles in the plant: it is involved in the activation of more than sixty enzymatic systems in the plant cell, and in the synthesis of proteins, vitamins, starch and cellulose which ensure normal plant metabolism, plant growth and formation of strong tissues. Potassium helps photosynthesis, the process through which the sugars and energy that the plant needs for its development are formed and converted. Potassium also controls the opening and closing of the leaf stomata, which regulate the water status in the plant. It plays an essential part in the formation of starch and in the production and translocation of sugars.

Potassium is, therefore, of special value to carbohydrate-rich crops such as sugarcane, potato and sugar beet. The production of starch and sugar in legumes boosted by potassium benefits the symbiotic bacteria living on the roots and and thus improves the fixation of nitrogen. Potassium not only increases yields but also enhances crop quality. It improves the nutritive value of grains, tubers and fruits by increasing the contents of protein and oil in seeds, of starch in tubers and seeds, and of vitamin C and sugar in fruits. With an adequate supply of potassium, cereals produce plump grains and strong stalks. Potassium also improves the flavor and color of fruits and increases the size of tubers and fruits. In addition, it increases the resistance to various injuries during storage and transportation, thus extending shelf life.

Sulphur

Sulphur (S) is an essential element in forming proteins, enzymes, vitamins, and chlorophyll in plants. It is crucial in nodule development and efficient nitrogen fixation in legumes. Protein synthesis requires large amounts of Sulphur, especially in the formation of oils within the seed, and Sulphur is a constituent of several amino acids and vitamins found in both plants and animals. Thus, Sulphur is an important factor in determining the nutritional quality of foods.

Sulphur is also important in photosynthesis and contributes to crop winter hardiness. An adequate supply of Sulphur is very important, not only for crops with high sulfur requirements - such as legumes (alfalfa, clover, soybean etc.) and Cruciferae (canola, rapeseed) - but also for crops with high nitrogen requirement (corn, cotton), which without Sulphur cannot optimize their utilization of nitrogen.

Sulphur is one of the 17 essential plant nutrients. It is essential for the growth and development of all crops, without exception. Like any essential nutrient, sulphur also has some key functions in plants like formation of chlorophyll that permits photosynthesis through which plants produce starch, sugars, oils, fats, vitamins and other compounds. Protein production. Sulphur is a constituent of three S-containing amino acids (cysteine, cystine and methionine), which are the building blocks of protein. About 90% of plant S is present in these amino acids. Synthesis of oils. This is why adequate sulphur is so crucial for oilseeds. Activation of enzymes, which aid in biochemical reactions in the plant. It Increases crop yields and improves produce quality, both of which determine the market price a farmer would get for his produce. With reference to crop quality, Sulphur improves protein and oil percentage in seeds, cereal quality for milling and baking, marketability of dry coconut kernel (copra), quality of tobacco, nutritive value of forages, etc. It is associated with special metabolisms in plant and the structural characteristics of protoplasm.

Boron

Boron (B) is a micronutrient critical to the growth and health of all crops. It is a component of plant cell walls and reproductive structures. It is a mobile nutrient within the soil, meaning it is prone to movement within the soil. Because it is required in small amounts, it is important to deliver Boron as evenly as possible across the field. Traditional fertilizer blends containing Boron struggle to achieve uniform nutrient distribution. Despite the need for this critical nutrient, Boron is the second most widespread micronutrient deficiency problem worldwide after zinc.

Boron plays a key role in a diverse range of plant functions including cell wall formation and stability, maintenance of structural and functional integrity of biological membranes, movement of sugar or energy into growing parts of plants, and pollination and seed set. Adequate Boron is also required for effective nitrogen fixation and nodulation in legume crops. Boron deficiency commonly results in empty pollen grains, poor pollen vitality and a reduced number of flowers per plant. Low Boron supply can also stunt root growth.

Boron is responsible for cell wall formation and stabilization, lignification's and xylem differentiation. Boron deficiency causes a remarkable decrease in the production of indole acetic acid (IAA) which induces Calcium deficiency. It imparts drought tolerance to the crops. Boron plays pivotal role in pollen germination and pollen tube growth in cereals and oilseeds. Boron regulates K/ Ca ratio and sugar translocation in tuber crops like potato, sugar beet, etc. It is essential for cell division & protein synthesis. It facilitates the transport of Potassium in guard cells.

Most crops are not able to mobilize Boron from vegetative tissues to actively growing, meristematic plant tissues such as shoots, root tips, flowers, seeds or fruits. Rather, Boron transport occurs primarily in the xylem channel, resulting from transpiration. Because of this, deficiency symptoms first develop in newly developed plant tissue such as young leaves and reproductive structures

Zinc

Zinc, one of the essential micronutrients and an important constituent of several enzymes and proteins, is only needed by plants in small quantities. However, it is crucial to plant development, as it plays a significant part in a wide range of processes. The normal range for zinc in plant tissue is 15-60 ppm and in the growing medium between 0.10-2.0 ppm. Zinc deficiency or toxicity does not occur often; however, they both negatively impact crop growth and quality. Any deficiency or toxicity has to be addressed before crop damage is irreversible.

Zinc activates enzymes that are responsible for the synthesis of certain proteins. It is used in the formation of chlorophyll and some carbohydrates and is used in the conversion of starches to sugars. Zinc also helps plant tissue withstand cold temperatures. Zinc is essential in the formation of auxins, which help with growth regulation and stem elongation.

When the supply of zinc to the plant is inadequate, one or more of the many important physiological functions of zinc is unable to operate normally and plant growth is adversely affected. The changes in plant physiological mechanisms brought about by a deficiency of zinc can result in the plant developing visible symptoms of stress which might include one or more of the following: stunting (reduced height), interveinal chlorosis (yellowing of the leaves between the veins), bronzing of chlorotic leaves, small and abnormally shaped leaves and/or stunting and rosetting of leaves (where the leaves form a whorl on shortened stems). These different types of symptoms vary with plant species and are usually only clearly displayed in severely deficient plants. In cases of marginal deficiency, plant yields can often be reduced by 20% or more without obvious visible symptoms. This is called 'hidden', 'latent' or 'subclinical' deficiency. Zinc-deficient soils causing hidden deficiency may remain undetected for many years unless soil or plant diagnostic tests are carried out, because there are no obvious signs of stress in the crops growing on them.

However, a change to growing less zinc deficiency tolerant crop species or cultivars, or the adoption of more intensive farming methods may lead to the development of a more severe deficiency in the crop accompanied by visible symptoms which will bring the problem to the notice of the farmer. Losses of yield of 20% or more as a result of hidden zinc deficiency can have an economic impact on the farmer. In more intensive types of arable farming where expensive inputs of seed, fertilizers, agricultural chemicals and possibly irrigation water are involved, the failure of crops to realize their potential yield is a major loss of income to the farmer. In developing countries, the cost to the nation from significant shortfalls in food production is also considerable because increased imports of grain will often be required to make up this shortfall.

Many plant species are affected by zinc deficiency on a wide range of soil types in most agricultural regions of the world. The major staple cereal crops: rice, wheat and maize are all affected by zinc deficiency, together with many different fruit, vegetable and other types of crops including cotton and flax. Maize is the crop species which is most susceptible to zinc deficiency and, in many countries, it receives the highest proportion of zinc fertiliser applications. Rice is also highly susceptible to zinc deficiency, especially that grown in lowland (paddy) production systems, because the chemical conditions in the waterlogged soils are conducive to zinc deficiency.

Manganese

Manganese (Mn) is a distinctly favorable micronutrient that plants essential for optimum growth. Manganese plays an important role in many physiological processes such as photosynthesis and acts as an activator or cofactor in at least 35 enzymes and is involved in metabolic processes. It is a constitutional element of the photosystem-II water oxidizing system and donates in chlorophyll production. Manganese and zinc (Zn) are closely related due to their participation in enzyme systems. Manganese ion (Mn2+) is transformed to Mn3+ or Mn4+ easily where Mn plays a vital role in oxidation and reduction processes by electron transport in photosynthesis. An important antioxidant such as SOD (superoxide dismutase) is the structural part of Mn that inhibits the formation of free radicals in plant cells, which destroys plant tissue.

Involvement of Mn in protecting plants against. As a mineral element, it is nutritionally required while at the same time can be toxic. The need for micronutrients as Mn for plants was first found in 1922. Manganese is of critical concerns in both plant and soil by two ways with its deficiency on the one hand and its toxicity on the other. In both cases there is a reduction in the yield and growth of the crop and a negative affect on the biochemical processes of the soil. The amount of Mn varies from soil to soil. The total amount of Mn in the soils fluctuates between 20 to 3000 ppm and on average it is 600 ppm. It participates in many complex and uneven reactions in the soil such as oxidation reduction, ion exchange, specific adsorption and solubility equilibria etc.

The amount of available Mn in the soil is affected by soil pH, organic matter, moisture and soil aeration. As the pH of the soil decreases, the availability of Mn increases in the soil. Lack of Mn in alkaline soils is very common which limits the growth and yield of plants. Manganese deficiency is widespread but calcareous soils, soils with high pH and low ventilation are mainly Mn deficient.

The critical level of Mn varies depending on the cultivar, crop species and environmental conditions and its range from 10 to 50 μg g-1 dry matters. Low levels of Mn as an essential micro nutrient are necessary for normal nutrition and growth of plants. The content of Mn in the leaves of the crop species varies from 30 to 500 mg kg-1. If excessive amounts of Mn are present, it is extremely toxic to the plant cells. Manganese usually accumulates in the peripheral cells of the leaf petiole and palisade and spongy parenchymatous cells. Toxicity of Mn in acidic soils is an important feature that inhibits plant growth.

Plant growth and photosynthesis are reduced if the soil contains high levels of Mn. Mn toxicity usually starts when the soil pH is 5.5 or lower but it is seen when the soil pH is less than 6.0. Crop species such as wheat, soybean, mustard and common beans are very sensitive to Mn deficiency and they respond positively to the application of Mn fertilizer. Lack of Mn in the above-mentioned crops results in reduced dry matter production and yield, weakens the immune system against pathogens and decreases heat and drought resistance.

Intensive cropping, cultivation of high yielding crop verities, imbalanced fertilization without micronutrients, little or no use of organic manures have resulted in depletion of micronutrients in Bangladesh soil.

Nickel

Nickel is a plant micronutrient. It contributes to nitrogen fixation and the metabolism of urea (a nitrogen containing compound) and is important for seed germination. Nickel is also important for bacteria and fungi, which are both important for good plant growth.

Nickel is a key component of selected enzymes involved in N metabolism and biological N fixation and is generally accepted as an essential ultra-micronutrient. It is a well-known functional constituent of seven enzymes, many of which occurring in bacterial and animal systems, but not known to be active in plants. A seventh enzyme, urease, is widely distributed in biology which catalyzes the hydrolytic cleavage of urea to give ammonia and carbon dioxide. It is widely distributed in higher plants.

Nickel usually works as a cofactor to enable urease to catalyze this conversion. It is used as a source of Nitrogen for plant life. Its metabolism is very critical for certain enzyme activities other than urease, such as glyoxalases (family I), peptide deformylases, methyl-CoM reductase, some superoxide dismutases and hydrogenases, in maintaining proper cellular redox state and various other biochemical, physiological and growth responses. It gets accumulated in plant organs or tissues, such as leaves. A broader biological significance of nickel is also implied in the demonstration that nickel is essential for animal life and for a range of bacterial enzymes, including key enzymes in the nitrogen-fixing symbiont, Bradyrhizobium japonicum.

Many examples were cited for yield increases in field-grown crops in response to Nickel application to the crop and to the soil. Nickel application benefited the growth of nitrogen-fixing plant species. It was reported that soil-Nickel application to field-grown soybean resulted in a significant increase in nodule weight and seed yield. The role of nickel in plant growth and metabolism emerged as a topic of interest after the discovery of Nickel as an important component of the plant urease in 1975 and was reported that when tomato and soybean plants were grown in hydroponic cultures with insufficient Nickel and supplied with urea as the nitrogen source, urea accumulated in their tissues and developed leaf tip necrosis.

Nickel also plays vital role in urea metabolism in. Nickel is an essential nutrient for both monocotyledons and dicotyledons for completion of plant life cycle, based upon the criteria for essentiality. Plants Nickel requirement is the lowest of all essential elements at < 0.5 mg kg-1 of dry weight, which makes it an essential plant micronutrient.

Nickel occupies a unique position among all the plant nutrients because its functions in plant growth and development. Nickel is available in the form of divalent cation (Ni2+) for uptake in plants, however total Nickel concentration is not a useful measure for Nickel bioavailability. It is the only oxidation state of Nickel that is likely to be of any importance to higher plants. Generally, about 0.1-5 mg kg-1 of Ni is present in the plants.

The values in excess of 200 mg kg1 may occur in some plant species in case of serpentine soils. Such levels may be toxic to plants which are not adapted to these soils. It is a well known fact that almost all the transition elements have a unique property to form coordination compounds.

Lead

Lead naturally occurs in soil at low levels. Hundreds of years of human activities have contributed to increased levels of lead in soil, especially in and around urban areas and near older homes. Lead does not breakdown over time, so lead deposited in the past can still be a problem today. Lead in soil can contribute to overall environmental lead exposure.

Higher levels of lead are found in soil if it is near roadways as a result of air emissions from vehicles that used leaded gasoline or it is near the perimeter of buildings that used lead paint that deteriorated as chips and dusts, or from past renovation activities Lead may also be found at high levels in soil near toxic waste sites and other areas close to industrial sites that release lead into the environment.

Cadmium

Globally, cadmium (Cd) contamination in soils has become a serious concern for environmental and human health, especially in developed countries experiencing rapid industrialization and practicing intensive agriculture. In recent years, cadmium (Cd) contamination in agricultural soils and its subsequent transfer to crops is one of the high-priority environmental and public health issues of global concern, especially in densely populated developing countries like Bangladesh. Cd concentration in rice of Bangladesh was the highest than that of USA, Japan, France, Italy, Spain, Cambodia, Ghana, India, Nepal, Sri Lanka, and Thailand. Among all the anthropogenic influences, repeated and excessive application of inorganic fertilizers along with pesticides is considered to be the major source of Cd as well as other metallic contamination in agricultural soils. Among the inorganic fertilizers, phosphate fertilizers are used intensively for alleviating phosphorus (P) deficiency which has been reported in about 43% of the global soils. Phosphate fertilizers are produced from non-renewable phosphate rocks, some of which also contain appreciable quantities of non-essential toxic heavy metals.

Chromium

Most chromium (Cr) exists in oxidation states ranging from 0 to VI in soils but the most stable and common forms are Cr(0), Cr(III), and Cr(VI) species. Chromium can have positive and negative effects on health, according to the dose, exposure time, and its oxidation state. The last is highly soluble; mobile; and toxic to humans, animals, and plants. On the contrary, Cr(III) has relatively low toxicity and mobility and it is one of the micronutrients needed by humans. In addition, Cr(III) can be absorbed on the surface of clay minerals in precipitates or complexes.

Thus, the approaches converting Cr(VI) to Cr(III) in soils and waters have received considerable attention. The Cr(III) compounds are sparingly soluble in water and may be found in water bodies as soluble Cr(III) complexes, while the Cr(VI) compounds are readily soluble in water. Chromium is absorbed by plants through carriers of essential ions such as sulfate. Chromium uptake, accumulation, and translocation, depend on its speciation. Chromium shortage can cause cardiac problems, metabolic dysfunctions, and diabetes. Symptoms of Cr toxicity in plants comprise decrease of germination, reduction of growth, inhibition of enzymatic activities, impairment of photosynthesis and oxidative imbalances.

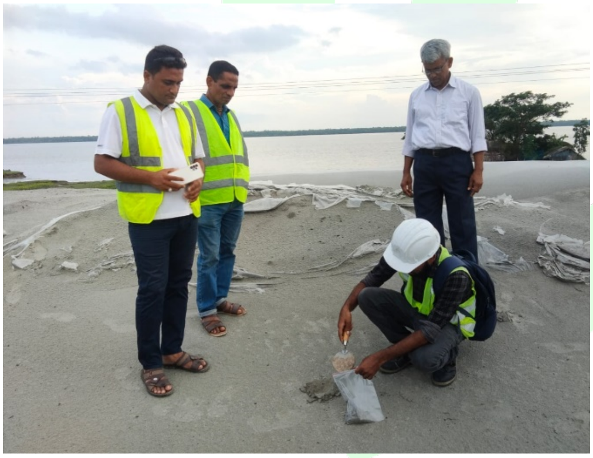
Methodology

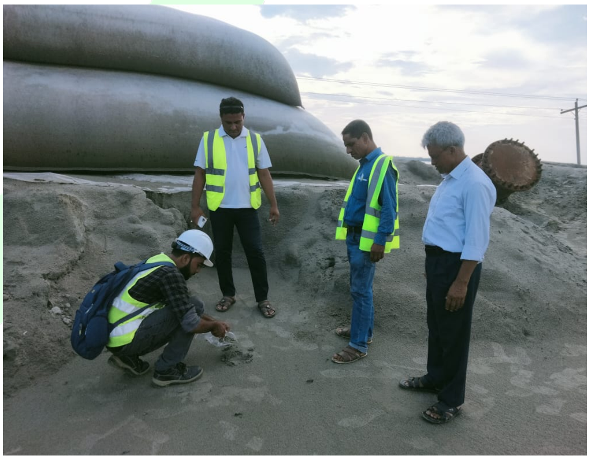
GREENBUD Testing and Inspection Services Pvt. Ltd. was hired to collect sample and analyze the soil sample from two locations of Kolabari and Sundortola, Chila, Mongla, Bagerhat. GREENBUD has collected samples following standard sampling method and generated report after analyzing in lab. The result of the collected samples were analyzed by experts in the field of soil science, agriculture, environmental impact and cultivation specialist.

Sample Collection method

Soil samples were collected using a stainless trowel or shovel from the top 10 cm depth (surface soils). Specimens were deposited into a stainless-steel tray and will be stirred into a homogenous mixture. Samples were then placed into one 250 ml glass jar. Then the soil samples were transferred into the sample collection bag, which was perfectly sealed; thus, Specimen was prevented from the air or any other contamination. Then Sample collector explicitly identified the sealed sample bag with the sample location, date, and sampling time. Then Sample collector submitted the individual sample bag to the lab.

To make sure the testing of those sample remain impartial both of the sample was tested in two government laboratory. One sample was sent to Soil Resource Development Institute (SRDI) of Ministry of Agriculture and another sample was sent to Bangladesh Council of Scientific and Industrial Research (BCSIR).





Soil Test Analysis Result

S/l	Soil Quality Parameters	Unit	Sample-1	Sample-2	Desired Value[2]
1	Arsenic (As)	ppm	**2.18**	**1.57**	**-**
2	pH	-	**7.6**	**8.2**	6 to 8
3	Organic Matter (OM)	%	**0.42**	**0.54**	2 to 8%
4	Total Nitrogen (TN)	%	**0.02**	**0.03**	-
5	Salinity (EC)	dS/m	**0.13**	**0.08**	Less than 0.08
6	Phosphorus (P)	ppm	**3.54**	**2.84**	30 to 50
7	Sodium (Na)	$Cmol^{+}/kg$	**0.097**	**0.037**	-
8	Potassium (K)	ppm	**27.3**	**19.5**	40 to 80
9	Sulphur (S)	ppm	**12.85**	**11.05**	30 to 40
10	Boron (B)	ppm	**0.12**	**0.05**	0.5 to 4.0
11	Zinc (Zn)	ppm	**0.14**	**0.99**	1 to 200
12	Manganese (Mn)	ppm	**3.75**	**2.56**	2 to 25
16	Nickel (Ni)	ppm	**5.77**	**7.43**	-
14	Lead (Pb)	ppm	**BDL**	**BDL**	-
15	Cadmium (Cd)	ppm	**BDL**	**BDL**	-
16	Chromium (Cr)	ppm	**7.80**	**9.95**	-

[2]Minnesota Pollution Control Agency . (n.d.). *Soil chemical properties and processes soil chemical properties and processes*. Soil chemical properties and processes - Minnesota Stormwater Manual. Retrieved September 23, 2022, from https://stormwater.pca.state.mn.us/index.php?title=Soil_chemical_properties_and_processes#:%20~:text=Soil%20chemical%20properties%20include%20concentrations,sodium%20adsorption%20ratio%2C%20enzymes%2C%20and

Discussion & Recommendation

The soil samples were tested for the above parameters to assess the suitability of agriculture. Among them Phosphorus, Sodium, Sulphur, Potassium, Boron, Manganese and Zinc are essential nutrients (micro and macro nutrients) for plants growth and health. Supplemental fertilization is needed if any deficiency of these ions occurs. Effects of the obtained results are discussed below:

- Parameters such as Phosphorus, Sulphur, Potassium, Boron and Zinc was found below the desired level which is very essential nutrients for plants and animal in Agricultural land. However, Manganese was found within the desired level.
- Organic matter plays many important roles in soil, including providing nutrients, improving soil physical properties (e.g., structure, porosity, and infiltration), retaining pollutants, and stabilizing soil pH and buffering capacity. However, it was found in the test results that organic matter has been found less than desired range.
- pH level of soil sample-1 (Kolabari) was found within the desired level while pH level of sample-2 (Shundortola) was found higher compared to the desired level. Higher level of pH can affect many soil processes such as microbial activity and mobility of nutrients.
- Salinity level of both soil sample-1 and soil sample-2 have been found greater than the desired level. High salinity hampers yield and is hard to mitigate. High salinity reflects soils with high sodium concentrations, which negatively impacts soil structure and transport of nutrients.
- The European Union (EU) recommends arsenic contamination levels to be within 20 ppm (or mg/kg) for agricultural soils.[3] The arsenic levels in the soil samples are 1.57-2.18 ppm (or mg/kg). By EU standards, the arsenic levels in the soil samples are suitable for agricultural use.
- Heavy metals like Zn, Ni, Pb, Cd, and Cr are considered pollutants for soil. The WHO standards for these metals are as follows: Zn (50 ppm), Ni (35 ppm), Pb (85 ppm), Cd (0.8 ppm), and Cr (100 ppm).[4] The heavy metals found in our two soil samples are as follows: Zn (0.14-0.99 ppm), Ni (5.77-7.43 ppm), Pb (below detection limit), Cd (below detection limit), and Cr (7.8-9.95 ppm). The heavy metals detected in the soil samples are within permissible limits for soil.
- Soil organic matter significantly improves the soil's capacity to store and supply essential nutrients (such as nitrogen, phosphorus, potassium, calcium and magnesium), and to retain toxic elements. It allows the soil to cope with changes in soil acidity, and helps soil minerals to decompose faster. In our sample the soil organic matter is lower than the expected limit. So it will have adverse impact on crop production.
- Phosphorus in plants is key in capturing, storing, and converting the sun’s energy into biomolecules, such as adenosine triphosphate (ATP), that drive biochemical reactions

[3] Rahaman S, Sinha AC, Pati R, Mukhopadhyay D. Arsenic contamination: a potential hazard to the affected areas of West Bengal, India. Environ Geochem Health. 2013 Feb;35(1):119-32. doi: 10.1007/s10653-012-9460-4. Epub 2012 May 18. PMID: 22618763.
[4] World Health Organization (WHO) (1996) Permissible Limits of Heavy Metals in Soil and Plants. Geneva, Switzerland.

(e.g., photosynthesis) from germination through the formation of grain to maturity. Phosphorus is present in deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), which store information on how plants should perform routine functions such as synthesizing proteins, lipids, and nucleic acid and metabolizing sugars. Phosphorus promotes early root growth, winter hardiness, and seed formation, stimulates tillering, and increases water use efficiency. So the inadequate amount of Phosphorus as we found in both of the samples this soil will stunts vegetative growth and grain yield.

- Potassium is a critical nutrient that plants absorb from the soil, and from fertilizer. It increases disease resistance, helps stalks to grow upright and sturdy, improves drought tolerance, and helps plants get through the winter. But in both of our samples the level of potassium was lower than the expected value. In this soil, the crop will not get proper nutrient which will hamper the cultivation.
- Sulphur is used in the formation of amino acids, proteins, and oils. It is necessary for chlorophyll formation, promotes nodulation in legumes, helps develop and activate certain enzymes and vitamins, and is a structural component of two of the 21 amino acids that form protein. The level of Sulphur is lower in both of the samples which will can result in reduced crop growth and yield.
- Boron plays a major role in the cell wall biosynthesis that primarily influences many growth factors including root elongation, tissue differentiation, pollen germination, pollen tube growth, and cell membrane functions. Boron levels in both of the samples are lower than the expected value which will impact the growing tips of the root or shoot, and generally include stunting and distortion of the growing tip that can lead to tip death, brittle foliage, and yellowing of lower leaf tips of the crops.
- Zinc is a micronutrient required by plants to produce chlorophyll. When there is a zinc deficiency in the soil, like we have in the sample 1, the result is discolored leaves and stunted growth of the crops.

As per the aforementioned test results, **the collected soil media is not suitable in its current state for paddy or any other crop cultivation, particularly due to its high salinity.** Intensive management and expensive inputs will be required to make the soil cultivable for the common crops in Bangladesh in areas impacted by the Mongla Port Authority's sand dumping.

Engr. Syed Tasnem Mahmood
CEO and Chief Environmental Engineer
GREENBUD
MIEB No.: M/35960
ISO 14001 certification Number.: EA/15/IN/16050
ISO 50001 certification Number.: ENMS/16/IN/533

Annexure

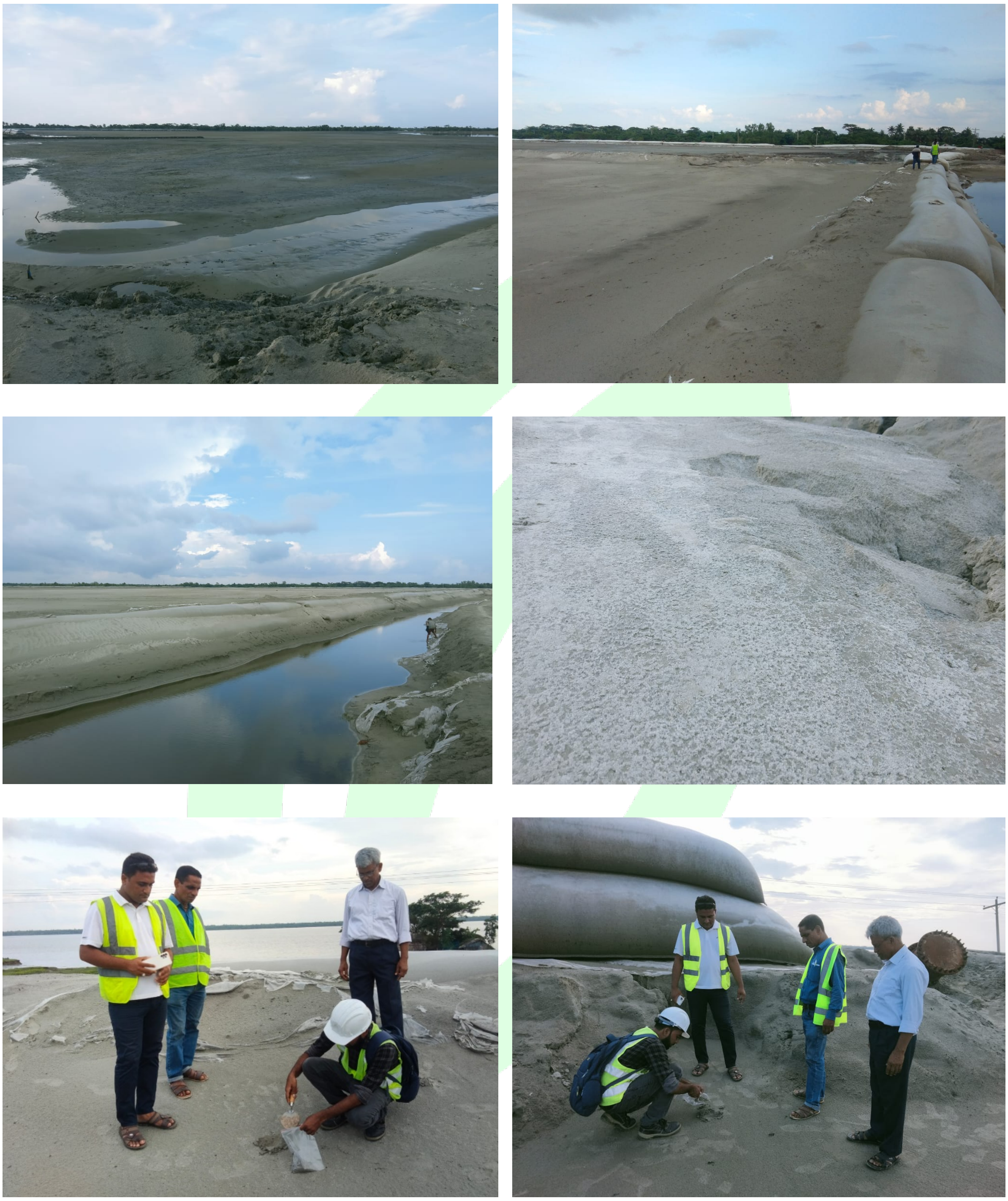


Figure: Pictorials of Site Surrounding and Soil Sampling

Government of the People's Republic of Bangladesh
Ministry of Agriculture
Soil Resource Development Institute
Divisional Laboratory, Dhaka
Mirttika Bhaban, Krishi Khamar Sarak, Dhaka-1215.

To
Fayez Ahammad
Executive (Operation)
GREENBUD
Shahjadpur, Gulshan
Dhaka- 1212.

Analytical Result of Supplied Soil Samples

Sl. No.	Lab. No.	Name of the Element															
		pH	Organic Matter (OM)	Total Nitrogen (TN)	Salinity (EC)	Phosphorus (P)	Sodiam (Na)	Potassium (K)	Sulphur (S)	Boron (B)	Zinc (Zn)	Manganese (Mn)	Nickel (Ni)	Lead (Pb)	Cadmium (Cd)	Chromium (Cr)
					dS/m	Available	Exchangeable		Available				Total			
			(%)			(ppm)	(Cmol$^+$/kg)		(ppm)							
1.	6526	7.6	0.42	0.02	0.13	3.54	0.097	0.07	12.85	0.12	0.14	3.75	5.77	BDL	BDL	7.80
2.	6527	8.2	0.54	0.03	0.08	2.84	0.037	0.05	11.05	0.05	0.99	2.56	7.43	BDL	BDL	9.95

*BDL=Below the Detection Limit

M. Begum
21/09/2022
(Dr. Masuda Begum)
Senior Scientific Officer
Phone: 02-41025066

Figure: Soil Test report from SRDI

জীবনের জন্য বিজ্ঞান "শেখ হাসিনার দর্শন, সব মানুষের উন্নয়ন"

বাংলাদেশ বিজ্ঞান ও শিল্প গবেষণা পরিষদ (বিসিএসআইআর)

BANGLADESH COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (BCSIR)

Laboratories / Institute / Center: **BCSIR LABORATORIES, DHAKA**

ANALYSIS REPORT

ASC Ref No. : D-534, Date : 31.08.2022	Unit (Lab/Inst.) Ref. No.: 534, Date: 31.08.2022
Sample Description :Test report on supplied samples (as mentioned)	Lab ID : SE 1449
Client's Detail: Fayez Ahammad, Executive (Operation), GREENBUD.	

Details:

Sample Details (as mentioned)	Parameter	Methodology/Instrument	Results
Soil Sample-1 (Location): Kolabari, S2	Arsenic (As)	Atomic Absorption Spectrophotometer with HVG	2.18 ppm
Soil Sample-2 (Location): Shundortola, S1	Arsenic (As)	Atomic Absorption Spectrophotometer with HVG	1.57 ppm

21.9.2022
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Dr. Md. Sarwar Jahan
Director
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Dr. Qudrat-i-Khuda Road
Dhaka-1205

Notes:

1. The results reported here pertained to the sample(s) received in this laboratory only.
2. Complain and/or query regarding test report(s) should be lodged within one month of report delivery date.
3. The laboratory is not responsible for the data quality affected due to sampling, transporting and storage conditions of the sample(s) maintained before received in the laboratory.
4. The report/result shall not be reproduced / published partly or fully without prior approval of the authority.

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Figure: Soil Test report from BCSIR