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How Can Soil Electrical Conductivity Measurements Control Soil Pollution?

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Abstract: Soil pollution results from the build up of contaminants, toxic compounds, radioactive materials, salts, chemicals and cancer-causing agents. The most common soil pollutants are hydrocarbons, heavy metals (cadmium, lead, chromium, copper, zinc, mercury and arsenic), herbicides, pesticides, oils, tars, PCBs and dioxins. Soil Electrical Conductivity (EC) is one of the soil physical properties which have a good relationship with the other soil characteristics. As measuring soil electrical conductivity is easier, less expensive and faster than other soil properties measurements, using a detector that can do on the go soil EC measurements is a good tool for obtaining useful information about soil pollution condition.

Key words: EC detector, environmental effect, soil electrical conductivity, soil pollution

INTRODUCTION

Until the 1970s, there was little talk of soil pollution and its devastating effects. In the 1980s, the U.S. Superfund was created to set guidelines for the handling of hazardous material and soil contamination cleanup. Today there are more than 200,000 sites awaiting EPA soil cleanup, which is a very expensive and labor-intensive work. Even a small cleanup project can cost $10,000, while larger areas require millions of dollars to clean it up for future use. The aim of this study is describing soil pollution and its effects on crops and finally showing the relationship between soil electrical conductivity and soil pollution factors.

How does soil get polluted? Soil is a sort of ecosystem unto itself, and it is relatively sensitive to foreign matter being applied to it. That's good for us in the case of wanting to add soil amendments, fertilizer and compost to make the soil healthier, but not so good when it comes to soil pollution. Soil health is defined as the continued capacity of soil to function as a vital living system, by recognizing that it contains biological elements that are key to ecosystem function within land-use boundaries (Doran and Zeiss, 2000; Karlen *et al*., 2001). These functions are able to sustain biological productivity of soil, maintain the quality of surrounding air and water environments, as well as promote plant, animal, and human health (Doran *et al*., 1996). There are many different ways that soil can become polluted, such as seepage from a landfill, discharge of industrial waste into the soil, percolation of contaminated water into the soil, rupture of underground storage tanks, excess application of pesticides, herbicides or fertilizers, solid waste seepage. The most common chemicals involved in causing soil pollution are petroleum hydrocarbons, heavy metals, pesticides, solvents. Soil pollution happens when these chemicals adhere to the soil, either from being directly spilled onto the soil or through contact with soil that has already been contaminated. As the world becomes more industrialized, the long term effects of soil pollution are becoming more of a problem all over the world. It is thought that a full 150 million miles of China's farmland is contaminated (Anonymous, 2010). In Asia, adverse effects on soil health and soil quality arise from nutrient imbalance in soil, excessive fertilization, soil pollution and soil loss processes (Zhang *et al*., 1996; Hedlund *et al*., 2003). In Africa, three quarters of farm land is severely degraded (Eswaran *et al*., 1997).

SOIL POLLUTION PROBLEMS

Soil pollution harms plants that feed people. Chemicals can sometimes absorb into food like lettuce and be ingested. Other times, the pollutants simply kill the plants, which have created widespread crop destruction and famine in other parts of the world. The entire ecosystem changes when new materials are added to the soil, as microorganisms die off or move away from contaminants.

Even when soil is not being used for food, the matter of its contamination can be a health concern. This is

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especially so when that soil is found in parks, neighborhoods or other places where people spend time. Health effects will be different depending on what kind of pollutant is in the soil. It can range from developmental problems, such as in children exposed to lead, to cancer from chromium and some chemicals found in fertilizer, whether those chemicals are still used or have been banned but are still found in the soil (Anonymous, 2010).

Some soil contaminants increase the risk of leukemia, while others can lead to kidney damage, liver problems and changes in the central nervous system. Those are just the long term effects of soil pollution. In the short term, exposure to chemicals in the soil can lead to headaches, nausea, fatigue and skin rashes at the site of exposure (Anonymous, 2010).

Environmental long term effects of soil pollution: Soil that has been contaminated should no longer be used to grow food, because the chemicals can leech into the food and harm people who eat it. If contaminated soil is used to grow food, the land will usually produce lower yields than it would if it were not contaminated. This, in turn, can cause even more harm because a lack of plants on the soil will cause more erosion, spreading the contaminants onto land that might not have been tainted before. In addition, the pollutants will change the makeup of the soil and the types of microorganisms that will live in it. If certain organisms die off in the area, the larger predator animals will also have to move away or die because they've lost their food supply. Thus it's possible for soil pollution to change whole ecosystems (Anonymous, 2010). Nawrot *et al.* (2006) have studied the effects of cadmium pollution in soil (around former thermal zinc plants) and found a significant increase in lung cancer risk correlated with cadmium exposure.

EC measurement in soil: Electrical conductivity (EC) is the ability of a material to transmit (conduct) an electrical current and is commonly expressed in units of milliSiemens per meter (mS/m). Soil EC measurements may also be reported in units of deciSiemens per meter (dS/m), which is equal to the reading in mS/m divided by 100.

Factors affecting soil EC: The conduction of electricity in soils takes place through the moisture-filled pores that occur between individual soil particles. Furthermore, the existence of some ions in the soil changes soil electrical conductivity value.

Salinity level: Increasing concentration of electrolytes (salts) in soil water will dramatically increase soil EC. The salinity level in the soils of most humid regions such as the Corn Belt is normally very low. However there are areas that are affected by Ca, Mg, chloride (Cl), sulfate (SO_4), or other salts that will have elevated EC levels (Doerge *et al.*, 1999). Many researchers have studied about the relationship between soil electrical conductivity and salinity level such as Eigenberg and Nienaber (1998, 1999, 2001), Mankin and Karthikeyan (2002), Herrero *et al.* (2003), Paine (2003), Kaffka *et al.* (2005).

Cation exchange capacity: Mineral soils containing high levels of O.M. (humus) and/or 2:1 clay minerals such as montmorillonite, illite or vermiculite have a much higher ability to retain positively charged ions such as Ca, Mg, potassium (K), sodium (Na), ammonium (NH_4), or hydrogen (H) than soils lacking these constituents. The presence of these ions in the moisture-filled soil pores will enhance soil EC in the same way that salinity does (Doerge *et al.*, 1999). Mcbride *et al.* (1990) and Triantafilis *et al.* (2002) have studied about the relationship between soil electrical conductivity and cation exchange capacity.

Herbicide usage: For controlling weeds in the farms, farmers used herbicides. The usage of herbicides must be proportional to the weeds dispersion in field. In many cases farmers use a great amount of herbicides to ensure that all weeds will be killed with herbicide. But they have no attention that if the herbicide use is more than required amount, its accumulation in soil will result soil pollution, which is so dangerous for plant and human life. Jaynes *et al.* (1995) have considered about the relationship between herbicide partition coefficients and soil electrical conductivity patterns.

SENSOR TYPES FOR MEASURING SOIL EC

There are two types of sensors commercially available to measure soil EC in the field. Sensor types are contact or non-contact. Measurements by both sensor types have given comparable results (Grisso *et al.*, 2007).

Contact sensor measurements: This type of sensor uses coulters as electrodes to make contact with the soil and to measure the electrical conductivity. In this approach, two to three pairs of coulters are mounted on a toolbar; one pair provides electrical current into the soil (transmitting electrodes) while the other coulters (receiving electrodes) measure the voltage drop between them. Soil EC information is recorded in a data logger along with location information. A Global Positioning System (GPS) provides the location information to the data logger. The contact sensor is most popular for precision farming applications because large areas can be mapped quickly and it is least susceptible to outside electrical interference.

Currently, Veris Technology (2006) manufactures a contact type of EC measuring device. The model can be pulled behind a truck at field speeds up to 10 mph. The

Fig. 1: The apparatus fabricated by authors for measuring apparent soil electrical conductivity

distance between measurements passes ranges from 20 to 60 feet, depending on the desired sampling density or the amount of soil variability within the field.

Because the Veris product is so expensive, the authors fabricated a similar apparatus for measuring apparent soil electrical conductivity in Iran farms (Fig. 1). The apparatus is ready to use in farms. The fabrication's cost is much less than the same foreign brand type.

Non-contact sensor measurements: Non-contact EC sensors work on the principle of electromagnetic induction (EMI). EMI does not contact the soil surface directly. The instrument is composed of a transmitter and a receiver coil, usually installed at opposite ends of the unit. A sensor in the device measures the resulting electromagnetic field that the current induces. The strength of this secondary electromagnetic field is proportional to the soil EC. These devices, which directly measure the voltage drop between a source and a sensor electrode, must be mounted on a non-metallic cart to prevent interference. These sensors are lightweight and can be handled easily by a single individual, thus making them useful for small areas.

CONCLUSION

Soil pollution is one of the major problems which threatens plant and people lives, results from seepage from a landfill, discharge of industrial waste into the soil, percolation of contaminated water into the soil, rupture of underground storage tanks, excess application of pesticides, herbicides or fertilizer, solid waste seepage. Soil electrical conductivity (EC) is one of the soil physical properties, which have a good relationship with the other soil characteristics. Measurement of apparent soil electrical conductivity is one of the easiest ways to get suitable information about soil characteristics. Beside easiness, the low price of measuring apparent soil electrical conductivity introduces it as the best way for obtaining useful information about soil pollution condition.

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