Biosolids Management – Acting Locally, Responding Globally

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Introduction

"Using a precautionary approach, recycling biosolids for agricultural use is an important strategy for soil health and community sustainability". I will unfold what this means practically in our communities. I will address the excellent questions regarding trace elements sometimes also called heavy metals, microbes, and emerging substances of concern.

"Acting Locally, Responding Globally" is a byline that states the obvious, all of us are doing this every day. As a scientist who has worked with soil and waste for almost 30 years, I participate with others around the globe to consider how we can live more sustainability on this planet.

We need to manage our leftover food in a way that is safe for ourselves and our communities. We in the nations who are more privileged than most in the world have the opportunity to develop, and to model sustainable management for the rest of the world. And as persons who have a shared responsibility on this planet, it is our obligation. We need to act locally, and respond globally.

A sustainable community is all about protecting and enhancing our soils. Historically, we recycled our organic matter, because we understood that it was important to return the nutrients and organic matter to the land to maintain soil health and productivity.

As our society becomes increasingly urbanized, we separated the growing of the food from returning the unused portion back to the land to benefit the soil. With the advent of chemicals and fertilizer, we tried to live in the illusion that the soil organic matter wasn't really that important. Today, our world is changing again, and more of us are realizing just how important our soil and our organic matter really is.

The Importance of Soil Organic Matter

Organic matter in our topsoil is important for providing nutrients, a home for healthy microorganisms that help plants fight disease, holding water so that not as much irrigation is required, and stabilizing the soil physically and chemically (King County Department of Natural Resources 1999, FAO 2005).

2015 is the International Year of Soils, as designated by the Food and Agriculture Organization. A quote from their website states *"Soil conservation is important because if we do not produce food, we do not eat"*

Objectives for the International Year of Soils include raising awareness about how important the soil is for human life, to educate the public about the crucial role soil plays in food security, climate change and mitigation, poverty alleviation and sustainable development.

In Canada, recycling of biosolids into agriculture is encouraged to *"serve as a source of non-fossil fuel derived organic matter and nutrients to promote plant establishment and growth, enhance soil fertility and structure and provide opportunities for carbon sequestration."* (CCME 2012)

Biosolids application in British Columbia resulted in *"increased aggregation and the accumulation of soil C within aggregates following biosolids application creates a potential for better soil C storage, soil water retention, nutrient availability, and ultimately the overall health of semiarid perennial pastures."* (Wallace et al. 2009).

Returning the nutrients and organic matter in biosolids back to agriculture safely is an important part of sustaining our soil. "Using a precautionary approach, recycling biosolids for agricultural use is an important strategy for soil health and community sustainability"

When we think of recycling our biosolids, and as we address the specific concerns about metals, microbes and emerging substances of concern, we have a few other global considerations, including world phosphorus reserves and quality, increased concern with antimicrobial resistance, and the ability of an agriculture dependent on the use of chemicals and pesticides to feed and sustain our world now and in the future.

Phosphorus Recycling

The first global factor that we need to consider locally is phosphorus. Phosphorus is essential for life. Its in our DNA, its in our bones. Its vital in transferring energy from the food that we eat to the muscles and other cells in our body. Our world's supply of phosphorus is finite, some estimates vary between 60 and 200 years. There is the easily extractable phosphorus, and there are the phosphorus reserves that are more difficult and expensive to extract. More than 70% of our remaining phosphorus is in North Africa (IFDC 2010).

We must do our best to recycle phosphorus that we have. Biosolids is one important source of phosphorus. Our current pattern of exporting food from agricultural land to our cities, and not returning the organic matter and phosphorus to the land breaks the phosphorus cycle and increases the demand for our finite phosphorus resource (Weinstein 2013).

What most of us don't realize is that most of our phosphorus supply contains trace elements such as arsenic, cadmium, chromium, lead, nickel and vanadium (Minnesota Dept of Health 1999, Finnish Environment Institute 2000, Roberts 2014, Sorensen et al. 2011). These trace elements in our phosphorus fertilizers are of international concern. The Europeans have been paying attention to this for some time now (Davelaar 2007, UK Occupational Health and Safety

2008). The organic food production industry is also paying attention to this as rock phosphate as well as some other products used for organic food production contain heavy metals (Baker and Tracy 2008).

Phosphorus fertilizer also contains radionuclides, such as radium, thorium and uranium (UK Occupational Health and Safety 2008, Khater 2008, LeMone et al. 2009, Akhtar and Tufail 2009, El-Taher and Makhluf 2010, Ragheb and Khasawneh 2010). The average uranium concentration in phosphate rock is reported to be between 50 and 200 mg/kg. Its important to understand that some of this is not removed when we manufacture fertilizer.

In response to heavy metals in phosphorous rock, the Soil Association in the UK in 2010 prepared a report entitled, "A Rock and A Hard Place, peak phosphorus and the threat to food security" (Soil Association 2010). They suggested that the *"majority of human excreta will need to be returned to a large proportion of agricultural soil to close the phosphorus loop"* They are advocating that changes be made to allow biosolids be used on organic certified land *"subject to certain quality criteria and appropriate restrictions, including maximum concentrations of heavy metals and organic contaminants"*

Trace Elements or "Heavy Metals"

Soils naturally contain trace metals or "heavy metals". This is especially true in our resource rich British Columbia. Biosolids also contain trace elements. Many of our biosolids in British Columbia have trace element concentrations up to two orders of magnitude lower than required for fertilizers under Canadian Regulation. Some of the fertilizers that we purchase locally may have more trace elements than the biosolids from our communities. The European Union considers trace element contributions from all sources, including fertilizers, biosolids, manures and other soil enhancement products (EU 2004, EU 2012).

In Canada, conclusions include: *"review of research involving long-term and larger than recommended biosolids application to land, and recent biosolids analyses indicate that Canadian trace metal guidelines/regulations are more protective than necessary for the production of high quality agricultural crops"* (Webber and Sidhwa 2007).

At typical soil pH values, only a very small percentage of metals originating from biosolids dissolve or become mobile (Diaz 2010). Heavy metals are immobilized due to organic material in biosolids through the formation of stable organic complexes (Usman et al. 2012).

Sweden established a target to recycle 60% of the phosphorus in urban wastewater by 2015, mostly by recycling biosolids into agriculture (Evans 2012). In Italy, sewage sludge from small and medium communities have relatively low heavy metal content and can be safely recycled in agriculture (Rizzardini and Goi 2014).

Antimicrobial Resistance

The second global factor that we need to consider is the increased concern with antimicrobials and antimicrobial resistance, or the 'Superbugs'. The World Health Organization in 2014 issued a recommendation to work collaboratively with human and veterinary medicine, agriculture, environment and consumers to address this increasing concern (WHO 2014).

It is very important to understand this in relation to biosolids management, but also manure management, and septic system management. In 2010, the National Academy of Sciences published a paper entitled: "Antibiotics in manure and soil, a grave threat to human and animal health" In this paper, they are suggesting that 30-80% of antibiotic doses fed to animals may be excreted as waste and enter the environment (NASA 2010). A 2014 report in Canada echoed these concerns (Grant et al. 2014). Development of antibiotic resistant bacteria is a major concern for us in our world.

Biosolids that have been properly managed to reduce potential pathogen risk is an important source of nutrients and organic matter in maintaining a sustainable soil system. The CCME (2012) notes that *"the greatest disparities between municipal biosolids and manure have been observed in microbiological content, with untreated manures carrying levels of E. coli and Salmonella several orders of magnitude higher than treated municipal biosolids."*

Septic systems are also an important contributor to microbial contamination in our watersheds. In a study of the Salmon River watershed, potential pathogen contamination of the water originated from animal manures, wild bird droppings, and septic waste (Jokinen 2010).

Feeding Our World

The third global factor that we need to consider is how we are going to feed our world now and in the future. We know that when we started using fertilizers in the 1800s, we came to what is called the green revolution. Some consider the increasing use of GMO crops and pesticides as the only way that we can feed our world in the future. An increasing number of experts and scientists are changing their mind on this. In 2010, the United Nations prepared a report entitled "Agro-ecology and the Right to Food" which suggests that agroecology can double food production within 10 years while mitigating climate change, protecting and enhancing our environment, and alleviating rural poverty (United Nations 2010). Agro ecology is all about sustaining our soil and managing our organic matter.

What happens to fertilizers and pesticides in our soil if there is little or no organic matter? Let's consider fertilizers first. We have seen that phosphorus containing fertilizers contain trace elements, some of which are of concern. We also know that these trace elements become more soluble, or can move in water more easily as the pH of the soil decreases. We know that

the pH of many soils in the world tend to decrease as a result of fertilizer application, and from rainfall. The same is true in BC.

One of the benefits of organic matter, including biosolids, is that they buffer the soil against pH changes. This means that the pH of the soil is less likely to decrease, and the trace elements of concern are less likely to become soluble.

This is the same reason why biosolids are used for mine reclamation. During our mining operations, we expose the soil, there is no organic matter, the pH can be low in many instances. This means that many trace elements become soluble and become a concern. The addition of biosolids increases the pH, the organic matter in the biosolids hang on tightly to trace elements, and the land can begin a restoration process. Biosolids are very important for mine site reclamation (Canadian Institute for Environmental Law and Policy 2008).

What about pesticides? When there is little organic matter in the soil, two things can happen. The pesticides move down through the soil faster because there is no organic matter to grab hold of them. The other important factor is that if there is not much soil organic matter, there isn't the same number of active microbes that can degrade the pesticides (FAO 2005, Briceno et al. 2007). Biosolids and other organic matter are very important to reduce the long term environmental impact of the pesticides that many of us are using.

Emerging Substances of Concern

Finally, we have the category called emerging substances of concern. There has been considerable research into this, especially in Europe where almost 50% of the biosolids are land applied (CCME 2009, Edwards et al. 2009, Clarke and Smith 2011, Clarke and Cummins 2014, EFAR 2014).

There are a few substances of concern such as some of the antibacterials found in body soaps and toothpaste. The concentrations in the biosolids were 10,000 times lower than concentrations found in commercial products like soap and toothpaste (Hebert 2011).

> *"Although municipal biosolids may contain a very wide range of pharmaceutical products, the minute concentrations of these substances appear insufficient to pose an additional risk to human health, compared to direct exposure to these compounds in daily life."* (Hebert 2011)

It is also important to note that most of these residual organic compounds quickly biodegrade in soil, especially in soils with sufficient organic matter and an active and healthy microbial population.

The authors of one of these reports noted that when making these comparisons with routine farming practices, it is important to keep in mind that every year, pesticides are applied to many of our soils, and pharmaceuticals are also found in animal manures (Hebert 2011).

In Europe, the trend is towards increasing the amount of biosolids being recycled into agriculture, particularly in response to the global need to recycle phosphorus (European Phosphorus Platform 2014). Because of this, there are a number of studies focussing on these emerging substances of concern (JRC 2012). The general consensus is that source control is most important because the concerns appear to be more of an issue for the effluents that we discharge into our waters than for the biosolids (JRC 2012).

Source control of potential substances of concern is the best approach to ensuring that these compounds do not result in environmental harm (CCME 2010, 2012). Globally, we are realizing that we just can't make our wastewater and biosolids disappear anymore.

Conclusions

The three global options for biosolids management include incineration, landfilling and land application. Incineration is costly and we need to mitigate potential air-borne contaminants. Landfilling is becoming no longer an option because of space and global warming concerns. Land application, particularly land application for agriculture is being increasing understood as the most sustainable long term solution for our biosolids. In Northern Europe, up to 80% of the biosolids are recycled back into agriculture. On average, almost 50% of biosolids in Europe were applied to land (EFAR 2014). Switzerland is the only country in the EU that banned the spreading of biosolids (Evans 2012). In the Netherlands, land application of biosolids is discouraged primarily because of the surplus of animal manure. The amount of biosolids applied to farmland is expected to increase in Europe (Food Safety Authority of Ireland 2008).

In Canada, 43% of biosolids are applied to land. A review in British Columbia in 2011 concluded the following: *"Soil amendment products such as PenGrow derived from Class A biosolids are very safe for application for landscaping purposes and home gardens by the general public. They present no significant public health threat to groundwater and surface water quality or disease transmission via aerosol dispersion to adjacent property."* (Stantec 2010).

A recent conclusion in Europe is that: *"heavy metals and organic compounds come from different sources including atmospheric deposit, fertilizers, pesticides and manure utilization. Compared to these activities, the contribution from biosolids is negligible."* (EFAR 2015)

However, we need to remain vigilant in what types of chemicals we are using, and where they end up – in our air, in our water or in our soil. In that, we need to keep asking the questions, but also understanding that many have or are already considering the potential risks associated with these compounds.

We are called to act locally and respond globally in all that we do, including managing our biosolids.

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