Sewage Sludge

Current Practices & the Best Solution

Contents

khull@ewscanada.com (604)282-7329 www.ewscanada.com

Executive Summary

Spreading Sewage Sludge on your land will poison your soil, kill your livestock, and get you sued; the class action suits are already gathering momentum. This document will help you understand the very troubling issues surrounding the campaign to sell sewage solids as benign fertilizer.

The document addresses the issue of spreading sewage sludge on land that is either used for directly growing food or is used on range land where livestock or wild animals consume it. This practice of spreading sewage on farmland predates the modern era; however, our city sewage sludge is not your grandfather's manure. Urban sewage now includes chemicals, heavy metals, pharmaceuticals, hormones, medical waste and pathogens that fundamentally change the implications of this practice.

The need to neutralize or remove the toxicity is obvious, and new technological advances will allow us to do this effectively and ecologically.

In the first section we review the current practice and the dangers it represents to the health of humans, livestock and wild animals. We support our position with a 2010 letter written by Dr. Marilyn Cameron, the DVM Chair, Biosolids & Waste Water Caucus for Biosolids Free Nova Scotia, explaining the issues in simple terms. We also borrow heavily from the works of www.usludgefree.org, whose principal has done a terrific job of researching and presenting the material.

In the second section we explain the legal implications of growing food in a substance that is unquestionably toxic. For the past 16 years we have seen a growing movement to challenge this practice in the courts and we have seen verdicts that are causing a rethink of this method of dealing with our waste.

There is an alternative to land-spreading of sewage sludge, however it's likely that governments are insisting on land-spreading and assuring the people (falsely) of its safety, because they simply don't know of the alternative. It turns out that many international studies have shown that Pyrolysis, an alternative to land-spreading, is the single best means of dealing with sewage sludge. We give a brief synopsis of nine such university studies, from five different countries.

Lastly, we talk about a specific pyrolysis technology (we more accurately call it thermolysis). The technology is Canadian owned and managed by EWS, and although the first plants have been manufactured in Europe, the company has plans to move manufacturing to Canada. The AATS solution is the most advanced pyrolysis solution in the world, which, in turn, makes it the best solution for processing sewage biosolids.

It can be noted that processing the sewage sludge is a two-step process that first separates the solids and water. Dried and pelletized waste produced in the first step is then processed by the reactor bank in the AATS plant. The solution for drying and pelleting the waste is a BC innovation which is manufactured in Abbotsford BC. The drying process neutralizes nearly 100% of the pathogens in the waste material, making the transportation of the waste to our plant a safe and clean process. The subsequent AATS process ensures that 100% of pathogens are killed, over 97% of pharmaceuticals are eliminated, all hormones and toxins are destroyed, and heavy metals are sequestered (locked in) in the biochar manufactured by the AATS plant.

The Situation on the Ground

We begin this section with a letter from a respected doctor in Nova Scotia. Dr. Marilyn Cameron has been a practising veterinarian in Kings County for 15 years. She is Chair of the Biosolids & Waste Water Caucus with the Nova Scotia Environmental Network and a founding member of No Farms No Food - a coalition of concerned Kings County citizens striving to preserve farmland for future generations.

Letter to Farmers from Biosolids Free Nova Scotia

Source: Submitted
Date: 09-Jul-2010

My name is Marilyn Cameron and I am Chair of the Biosolids & Waste Water Caucus with the Nova Scotia Environmental Network. Our Caucus firmly believes in the importance of supporting local farmers and our members shop in our communities and buy local at every opportunity. We agree that everyone benefits if agriculture succeeds and flourishes in Nova Scotia. Farming contributes significantly to our economy. However, we want to be assured that the foods produced in our province are, not only the freshest, but also the safest of foods produced anywhere.

We understand that treated sewage sludge (biosolids) is being utilized by some farmers on their crops or forage fields in Nova Scotia. We have concluded that, unless sewage waste is completely free of industrial, commercial, and hospital contaminants or pathogens, using the product as a soil additive or fertilizer on agricultural soils is too risky an endeavor to ensure public health and safety - even if "treated". Treatment processes are not able to remove or stabilize most pollutants in sludge and these chemical substances can linger in the environment for decades - potentially contaminating our food and water sources. It is of concern to various livestock specialists that certain contaminants in sewage sludge could be accumulating in the fats in meat or milk products of livestock animals or impacting their health. In addition, some toxins can be taken up by plants and others can leach into groundwater sources or can remain and accumulate in the soils for many years – according to numerous environmental scientists.

The Biosolids Caucus is quite concerned that farmers are not being provided adequate information about biosolids and the negative impacts that its use could have on your soils, groundwater and surface water sources, livestock health, and property values. Farmers will be the ones left paying the price for any damaged land, contaminated water, or human, wildlife and livestock illnesses, etc. Farmers may also suffer losses resulting from lack of consumer confidence in local foods. The government of Nova Scotia has relinquished all liability that results from the use of the product and has clearly indicated that the end users (farmers) will be held responsible for any negative outcomes.

We are hoping that your farm does not utilize biosolids to fertilize your crops/animal feeds. It would be a shame to diminish the gains made in the "buy local" movement recently. More and more consumers seem to want local foods which are safe, healthy and are environmentally sustainable. If your farm does not use biosolids, we would really appreciate hearing back from you so that we can add your farm's name to the list posted on the Nova Scotia Environmental Network's website.

Kindest Regards,
Dr. Marilyn Cameron, DVM Chair, Biosolids & Waste Water Caucus

www.usludgefree.org

The following synopsis is directly derived, with explicit permission, from the material at https://usludgefree.org. This organization has done a stellar job of collating a myriad of material, drawn from a variety of sources, and putting it in an easy to understand format. Accordingly, the following is a summary of the material collected by this impressive group.

The situation *on the ground*:

1. Farmers and ranchers do not know exactly what is being spread on their land; they are not given accurate information by those charged with spreading the sludge. For example, while municipalities point out that beneficial Nitrogen & Phosphorus are present in sewage sludge, the fact is that no two loads of sewage sludge have the same composition of chemicals or pathogens and the farmer runs the risk of an unbalanced application of (so called) supplements.
2. Sewage treatment plants don't produce fertilizer; they are not designed to. They are designed to concentrate waste material, not only from homes but from businesses, industry, hospitals, laboratories and funeral homes.
3. Testing standards and methodology for the biosolids is set to a remarkably low standard and would not be acceptable in other areas.
4. People have the misapprehension that these biosolids are like livestock manure, however this is far from the truth; by using human waste farmers are introducing human bacteria and pathogens into our food and water supply.
5. Toxic buildup over time isn't measured. The infrequent testing that is done doesn't consider the buildup of toxins over years of this practice.
6. Identifying toxins and other harmful pollutants is further complicated by the mystery as to where the biosolids are coming from. The biosolids may come from such a wide regional distribution that the businesses, industries and medical facilities that contributed to the sludge cannot be identified.

Are you really comfortable eating food grown in sewage?

There are well proven health and safety risks of growing food in toxic waste; when you really stop to think about it why would anyone conclude that eating vegetables grown in toxic material is good for you?

Think about the number of outbreaks of food poisoning we hear about in the news. When we hear that lettuce (for example) has E. coli contamination we assume it was from food-handlers, somewhere between the growing and the final sale, but is it possible that the source is nothing more than the sewage sludge the lettuce was grown in?

The fact of the matter is that foods grown in sludge-applied lands absorb the heavy metals hosted by the sewage sludge; this is only logical. Heavy metals build up in the soil over time, as they do not necessarily wash away, and so plants may continue to uptake heavy metals from the soil for years after sludge is applied. The amount of uptake into the vegetable is dependent somewhat on which crops are grown, as some are much more efficient in drawing up heavy metals. Also, it is important to note that plants can be affected by toxicity before they show it visibly, so one cannot rely on visual inspection to determine if the plant is safe to eat.

Cadmium and lead are heavy metals which have been linked to intestinal and kidney damage; they are easily taken up in products like carrots, potatoes, lettuce, spinach and grains. Crops can absorb a multitude of chemicals and pharmaceuticals, yet few jurisdictions test foods for any of the known toxins found in sewage sludge. Of course, labels are not mandatory for food grown in sewage sludge, so consumers have no way of knowing if they are consuming heavy metals and pharmaceuticals.

Additionally, in some parts of the US, recycled water from waste water treatment plants is used to irrigate crops, including strawberries and broccoli. Multi drug-resistant bacteria are found to survive the treatment process and be present in the finished water product. In Santa Barbara, California, the water effluent finished product of recycled water contained bacteria resistant to 11 of 12 antibiotics and were also chlorine-resistant. Water effluent is now recognized to carry the remains of many of our chemical and pharmaceutical by-products. For instance, recent studies have found that 75% of the key ingredient used in antibacterial hand soap, triclocarban, remains in sewage sludge even after it has been biologically treated for up to three weeks.

The stunning lack of research on the impact of toxins found in sewage sludge and applied to pastures is unsettling.

Dioxin, found in many samples of sewage sludge, gathers in meat, fats and milk and is a carcinogen and is known to cause birth defects. Many chemical contaminants and heavy metals found in sludge – including dioxin, PCBs, pesticides, some flame retardants and cadmium – tend to bio-accumulate in fat tissue and milk. Studies show that PCBs, dioxin and flame retardants all concentrate in breast milk and are extremely accessible to the nursing baby. Milk, in general, collects and accumulates dioxin, but testing of breast milk and the effect of it on babies has not been properly researched. Studies from respected universities, including Cornell University, have begun tracing the link between known toxins found in sludge and their infiltration into the plants and animals we consume.

SLUDGE DANGERS: FARMERS, AMERICA'S FOOD SOURCE & OUR FUTURE

Sewage sludge is falsely marketed to farmers as a fertilizer because it has measurable amounts of Nitrogen and Phosphorous, and by accepting the sewage sludge the farmer can save thousands of dollars normally spent on synthetic fertilizer.

But studies from Yale University in 2010 found that sludge/biosolids aren't heated high enough in the standard sewage treatment plants to kill all the pathogens. This is no surprise; in 2006, studies funded by the Water Environmental Research Foundation (WERF) – an arm of the sludge industry – noted that sludge/biosolids that were dewatered by centrifuge created a material that passed standard bacteria tests, yet just 20 minutes after dewatering, showed substantial increase in bacterial counts. WERF also released findings that confirm the re-growth of fecal coliform after treatment. Somehow science and industry have chosen to ignore the obvious – bacteria re-grow after treatment.

Dozens of chemicals found in the '2009 Targeted National Sewage Sludge Survey' are introduced into the environment, include neurodevelopmental toxins, which have been found to alter brain growth. Polychlorinated biphenyls (PCB), dioxin, brominated flame retardants and pesticides have all been found in sewage sludge. The use of sewage sludge on any open land means that America's toxic waste may be absorbed by crops and find their way up the food chain and into human diets.

CROP LOSSES

According to soil scientists at Cornell University Waste Management Institute, farmers using sewage sludge as fertilizer may experience reduction of crop production. In some cases, crop and livestock loss can take upwards of ten years to present as a noticeable problem. Test plots at Cornell University where sewage sludge was applied still are unable to sustain simple soil life like worms.

"Agricultural soils accumulate trace metals, particularly copper and zinc, as a result of their presence in sewage sludge/ biosolids and fungicides that are applied over a long period of time."

TOP DRESSING = SURFACE SLUDGE

Cattle and other livestock may also be allowed to graze on pastures with sludge 'top dressing' – the practice of spraying sludge on top of the foliage of a grazing field without plowing into the soil.

While grazing animals ingest soil as part of their food source, the EPA risk assessment assumes a mere 1.5% of animal's diet as soil intake. Yet poultry is known to consume soil in their general foraging diet in varying amounts; geese will consume as much as 8% of their diet as soil, wild turkeys will consume up to 9% and chickens and other poultry have been found to accumulate dioxins in their bodies. For some animals, like sheep, up to 30% of their diet is soil from grazing. Cattle ingest anywhere between 1% and 18% of the dry matter of soil or sludge while grazing. Wild animals also ingest foliage and soil in varying amounts and remain untested for health contamination. In communities where hunting is prevalent and game meat is part of the diet, sludge contamination should be considered a cause for concern.

Dr. Murray McBride, of the Cornell Water Management Institute, expresses concern with grazing animals on fields that have been 'top dressed', noting that '…. the animal can be ingesting something close to pure sludge.'

SLUDGE TURNS AMERICA'S FARMS INTO TOXIC DUMPS

Farmers throughout America, including Georgia, Vermont, Washington and Missouri, have been destroyed by the toxic pollutants in sludge. In some cases, such as United States vs. Cooper the farmer was charged and imprisoned for improper disposal of Class B sludge. In 2009, Missouri farms that received sludge marketed as a fertilizer from a tannery, were linked to an outbreak of brain cancer after contaminating the community with Hexavalent chromium, also known a Chromium 6.

In other cases, such as McElmurray v. Augusta-Richmond County, farmer Andy McElmurray accepted sludge to his 1,730 acres dairy farm only to witness the death of his land and lifestyle. With the filtered information and constant reassurance of safety of the sludge, Andy had no idea that the sludge contained levels of arsenic, toxic heavy metals and PCB's two to 2,500 times federal health standards. His cows died a slow and painful AIDS-like death while Andy searched for an answer. Finally, he discovered that the sludge he had been accepting as free and "safe" fertilizer was the cause of his problems. Even years after halting sludge application, his farm is still too toxic to support plants and livestock. In McElmurray's court case, Judge Alaimo stated, "senior EPA officials took extraordinary steps to quash scientific dissent, and any questioning of EPA's biosolids program."

Although McElmurray's neighboring farmer, Bill Boyce also won his court case, Boyceland Dairy v. City of Augusta, he lost his fourth-generation family farm after accepting sludge as a fertilizer for cultivation and grazing. Despite constant reassurance from sludge haulers and the city of Augusta, Bill witnessed the steady decline and death of his prize-winning dairy herd, known as Georgia's Boyceland Dairy. In

1999, Bill had independent testing performed on the milk from his cows. The stunning test results revealed high levels of thallium, molybdenum and cadmium. EPA lists thallium at a toxic heavy metal that can cause gastrointestinal irritation and nerve damage. Although the USDA regards thallium as one of the most dangerous agents of potential bioterrorism against the nation's food supply, thallium is not required for testing in sludge.

SLUDGE –BE CAUTIOUS

By using our human waste as a false fertilizer, we are introducing our own species bacteria and pathogens into our food and water supply. Land application of sewage sludge is no more than pollution transfer to the very source of our nourishment. A glance at the rise in infectious incidents in America's food supply and 5,000 annual deaths from food poisoning are true cause for alarm and necessitate 'connecting the dots.' Why are we pouring known toxic waste where we grow our food, gather our drinking water and raise our families? It's time to end our 'toilet-to-table' approach to food production.

It is interesting to note that some farming practices regarding the feeding of livestock in certain countries have been condemned here in North America because the fact is that, to an extent, one animal species feeds off the effluent of other animals. The negative health effects of this practice have been chronicled and we have restrictions on this practice in the West, does it then make sense that we have our livestock consume human effluent?

It is ironic to note that various governments around the world provide comprehensive guidelines on how livestock that will end up on our dinner table should be fed. There is, for example, is a document from the Australian government that says the following:

> *"Using plant-processing wastes, reject fruit and vegetables and other food wastes as livestock feed may seem to be a practical and economic way of using or disposing of such materials.*
>
> *However, people producing stock or animal products intended for human consumption should be aware that feeding any material that has not been produced specifically for use as stock feed can cause unacceptable chemical residues in animal products.*
>
> *Topics include:*
>
> - *residue risks*
> - *chemical residue risk assessments*
> - *prohibited substances in ruminant feeds*
> - *residue testing services"*
>
> *https://www.dpi.nsw.gov.au/animals-and-livestock/beef-cattle/feed/dangers-feeding-waste-material-livestock*

Here we have guidelines that would seem to preclude the use of sewage sludge as an additive; the sludge certainly contains "unacceptable chemical residues" and most certainly has not been "produced specifically for use as stock feed". This is an example of where governments abrogate their responsibility to protect our food sources because they simply have not felt the compunction to find a better solution to this contentious issue.

For more information we recommend the reader view the following two video links:

Trailer for the soon-to-be-released movie, "Biosludged": https://vimeo.com/202413146

Interview with Dr. David Lewis: https://vimeo.com/268845722

Also, we recommend the reader consider the following website: http://www.biosludged.com

Emerging Legal Challenges

There are dark clouds on the horizon for the sewage sludge industry. They have been very successful to this point in hiding the toxic nature of the sewage sludge they've been spreading on food producing and grazing lands, however thanks in large part to the information accessible through the web people everywhere are becoming aware of the practice and the toxic dangers of it.

In this section we point to examples where the courts are siding against the sewage spreading companies. Whole articles are presented here such that background information is available for edification and so that credit is given to those who have done the research and writing.

Courts Finally Recognize Spreading Sewage Sludge on Farmland Is A Very Bad Idea

March 7, 2008

Associated Press
by John Heilprin and Kevin S. Vineys
Environment & Climate, Farm Issues, Food Safety

from Yahoo! News

It was a farm idea with a big payoff and supposedly no downside: ridding lakes and rivers of raw sewage and industrial pollution by converting it all into a free, nutrient-rich fertilizer. Then last week, a federal judge ordered the Agriculture Department to compensate a farmer whose land was poisoned by sludge from the waste treatment plant here. His cows had died by the hundreds.
http://www.commondreams.org/archive/wp-content/photos/0307_01.jpg

The Associated Press also has learned that some of the same contaminants showed up in milk that regulators allowed a neighboring dairy farmer to market, even after some officials said they were warned about it.

In one case, according to test results provided to the AP, the level of thallium - an element once used as rat poison - found in the milk was 120 times the concentration allowed in drinking water by the Environmental Protection Agency.

The contaminated milk and the recent ruling by U.S. District Judge Anthony Alaimo raise new doubts about a 30-year government policy that encourages farmers to spread millions of tons of sewage sludge over thousands of acres each year as an alternative to commercial fertilizers.

The program is still in effect.

Alaimo ordered the government to compensate dairy farmer Andy McElmurray because 1,730 acres he wanted to plant in corn and cotton to feed his herd was poisoned. The sludge contained levels of arsenic, toxic heavy metals and PCBs two to 2,500 times federal health standards.

Also, data endorsed by Agriculture and EPA officials about toxic heavy metals found in the free sludge provided by Augusta's sewage treatment plant was "unreliable, incomplete, and in some cases, fudged," Alaimo wrote.

EPA-commissioned research by the University of Georgia based on the Augusta data was included in a National Academy of Sciences report and served as a linchpin for the government's assertion that sludge didn't pose a health risk.

In his 45-page ruling, Alaimo said that along with using the questionable data, "senior EPA officials took extraordinary steps to quash scientific dissent, and any questioning of EPA's biosolids program."

Benjamin H. Grumbles, EPA's assistant administrator for water programs, said Thursday that the judge's order underscored the significance of what he called strong national standards on sludge rather than undercutting the giveaway program.

"This unfortunate instance of poor recordkeeping and biosolids sampling techniques on the part of one plant reiterates the importance of our national biosolids program," Grumbles said in a written response to AP questions about the ruling.

About 7 million tons of biosolids - the term that waste producers came up with for sludge in 1991 - are produced each year as a by-product from 1,650 waste water treatment plants around the nation.

Slightly more than half is used on land as fertilizer; the rest is incinerated or buried in landfills. Giving it away to farmers is cheaper than burning or burying it, and the government's policy has been to encourage the former.

Alaimo's decision was a bittersweet victory for McElmurray, whose silos and dairy barns sit mostly empty since his herd was wiped out. He contends the cows were done in by grazing on sludge-treated hay for more than a decade, beginning in 1979.

Interviewed before the ruling, McElmurray crossed his arms, scowling at the empty pastures and idle equipment where his prize-winning herds once grazed here in eastern Georgia. "This farm never would have looked like this if we hadn't used the city's sludge," he said angrily.

The city of Augusta recently settled a lawsuit with him over the dead cows for $1.5 million. Another nearby dairy farmer, Bill Boyce, won a $550,000 court judgment against the city on his claim that sludge was responsible for the deaths of more than 300 of his cows.

The deaths of McElmurray's and Boyce's cows in the 1990s and their suits against Augusta raised a red flag with officials at EPA, which since 1978 had been promoting the use of sludge as a fertilizer.

In 1999, the agency awarded a $12,274 grant to the University of Georgia to study the problem. That research would result in a study published in 2003 in the Journal of Environmental Quality finding that the city's sludge was safe, and that EPA's regulations were working.

Cities' sewage and industrial pollution had spewed untreated into lakes, rivers and oceans until 1972, when Congress passed the landmark Clean Water Act.

Back then, cleaning up waterways was the first target of the newly created EPA. The agency oversaw a multibillion-dollar grant program that Congress set up to help cities and counties build wastewater treatment plants that would filter out pollutants.

Alaimo, citing data from an environmental engineer hired by McElmurray, found that the Augusta plant was sending out hundreds of truckloads of sludge daily with dangerously high levels of cadmium, molybdenum and chlordane.

The engineer, William Hall of Atlanta, had been a project manager at seven Superfund cleanup sites and had extensive experience with toxic chemicals and heavy metals. His tests found polychlorinated biphenyls or PCBs in the Augusta sludge at levels 2,500 times higher than the EPA standard, thallium levels 25 times the legal limit, and arsenic levels twice the government's health standard.

William Miller, a University of Georgia soil scientist who co-authored the 2003 study commissioned by EPA, stands by the conclusions it drew on how much sludge had been applied to McElmurray's and Boyce's land and the composition of it.

But in a draft of the paper obtained by The Associated Press, he wrote a note by hand saying the authors should "fess up" that they didn't know those things.

"Now, we didn't really know exactly how much sludge and we didn't know the quality of sludge," Miller told the AP in an interview. Despite the discrepancies, he maintained the study was valid. "It does not include fake data," he said.

Boyce told the AP that in January 1999 he informed Georgia dairy regulators and EPA that tests he had ordered on the milk from his cows had come back showing high levels of thallium, molybdenum and cadmium.

A top state official alerted the Food and Drug Administration, but Boyce said no one ever told him to stop selling his milk or mentioned a possible threat to public health.

"We were a little startled," Boyce recalled. "They concluded that our permit was good, and we could continue to sell milk. So, we did."

EPA lists thallium as a toxic heavy metal that can cause gastrointestinal irritation and nerve damage, but the agency has no standard on the metal's presence in milk. Neither does the Agriculture Department, even though it regards thallium as one of the most dangerous agents of potential bioterrorism against the nation's food supply.

State and EPA officials followed up by testing Boyce's milk, but he said they wouldn't share all their results with him or McElmurray. There is no evidence that those officials took any further action. Boyce said he decided finally to reveal the milk contamination to the AP to illuminate a broader issue.

"The real problem was the state and federal regulatory agencies did not do their jobs," he said, adding that EPA and Augusta officials "tried to say we were just a disease-infested herd. Well, that's just a bunch of bullhockey."

Charles Murphy, then head of Georgia's dairy program, said he notified FDA's Administration's office in Atlanta of Boyce's contaminated samples. "I know I talked to them some, shared some of that information with them," he recalled. "I don't think they sent anybody out."

Murphy said he was persuaded by evidence provided to him by Boyce and McElmurray to seek broader state testing of dairy cows, but there wasn't enough money.

FDA officials in Atlanta and Washington said they had no record of Murphy's account.

But over the Super Bowl weekend in 1999, two senior EPA officials, Robert Bastian and Bob Brobst, huddled with the two dairy farmers and their lawyer, Ed Hallman, to talk about sludge.

"They showed us some data," Bastian recalled. "I don't ever remember seeing any milk data."

Boyce and McElmurray insist they shared all of their data with the two EPA officials, including separate tests they ran on milk pulled from store shelves in Charleston, S.C. That milk, which came from other farms in the Southeast, suggested more widespread contamination, they said. It had heavy metals similar to those found in Boyce's milk.

There are no records that anyone became ill because of milk tainted with heavy metals or other contaminants that could have come from sludge.

On the Net: http://www.ag.auburn.edu/aaes/communications/highlights/fall96/cattle.htm

Biochar – Explaining the Science

In this section we look at a series of international studies that have identified a superior way of processing biosolids. This methodology creates a carbon substance called biochar, which has a myriad of benefits and has good market value. The following few paragraphs explain why creating biochar is so effective in managing the heavy metals that are in pretty much all sewage biosolids these days.

While adding biochar as a soil enhancement and using it for carbon sequestration, has gained widespread acceptance, the science behind the physical and chemical characteristics as to how this is accomplished has only recently received significant scientific research. We now know that the negative ion properties of biochar attract the positive cation charged ion elements and negative anion ion charged elements through the process of adsorption.

Simply put, the adsorbed ions attach to the surface area of the biochar particles and the elements containing positive ions such as Sodium, Potassium, Calcium, Magnesium and other metals create ionic compounds such as sodium chloride which are locked in the biochar. In contrast, the elements containing negative ions, such as Phosphorus, Nitrogen and Sulfur, are slowly released into the soil to act as fertilizing agents.

To summarize: through the above process, biochar retains and renders inert the toxic chemicals in the sewage sludge and enhances the slow release of nutrients safely into the soil.

The physical chemistry to gather ions on the biochar surface in a condensed layer is either accomplished by the processes described as the Cation Exchange (CEC) for positively charged elements or the Anion Exchange (AEC) for negatively charged elements. Each of these exchanges, either CEC or AEC, measure the capability of the biochar to adsorb each of the above ions.

International Studies on Pyrolysis as a Solution

Sewage sludge was pyrolyzed in order to assess the effect of pyrolysis temperature, residence time and biomass chemical impregnation on the yield of biochar production. The pyrolysis temperature was a key factor affecting biochar yield, while the highest yield was obtained at a temperature of 300 ◦C. Biochar surface area increased with increasing pyrolysis temperature and was maximized (90 m2/g) by impregnating biochar with K2CO3. Raw sewage sludge, as well as biochar samples, were subjected to leaching tests in order to investigate the potential release of heavy metals. Pyrolysis suppressed heavy metal release for the non-impregnated biochars, indicating that there is no environmental risk using sludge-derived biochars as soil amendments.

Biochar production by sewage sludge pyrolysis

Evita Agrafiotia, George Bourasa, Dimitrios Kalderisb, Evan Diamadopoulosa, ∗
[a] Department of Environmental Engineering, Technical University of Crete, 73100 Chania, Greece
[b] Department of Natural Resources and the Environment, Technological Educational Institute of Crete, 73100 Chania, Crete, Greece

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The production of sewage sludge has been sharply increasing by municipal sludge treatment plants in China. Sewage sludge is a difficult waste to manage not only due to the high quantities produced but also due to its high concentration of heavy metals and pathogens. The pyrolytic conversion of sewage sludge to biochar and then applied to the land is a sustainable management option. Therefore, the aim of this work is to evaluate the characteristics of nutrients and heavy metals in biochar from sewage sludge pyrolysis, and pot experiments were carried out with different treatments consisting of infertile and contaminated soils. The results showed that the content of major plant nutrients (N, P, K) in sewage sludge biochar meets agricultural requirements. The concentrations of heavy metals (Cu, Pb, Zn, Cd, and Cr) were evidently increased in biochar, but those of available heavy metals were decreased. The sewage sludge biochar can improve soil fertility and enhance plant growth while not increasing plant uptake of heavy metals, and remedied contaminated soil by reducing the plant availability of heavy metals.

Applying sewage sludge biochar to infertile and polluted soils promoted the plant growth and increased the fresh matter weight of Chinese cabbage. Heavy metals were not prone to bioaccumulation in the plant, and the plant availability of heavy metals was reduced in polluted soil.

Nutrients and Heavy Metals in Biochar Produced by Sewage Sludge Pyrolysis: It's Application in Soil Amendment

Taoze Liu[1], Bangyu Liu[2], Wei Zhang[2]
[1]State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550002, P.R. China

[2]Geography and Tourism Department of Guizhou Normal College, Guiyang 550018, P.R. China

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Experimental results revealed that biochars were rich in nutrient contents and they improved garlic yields. Although contents of heavy metals including As, Zn, Pb, Ni, Cd, Cr and Cu, etc. were elevated in the biochars compared to local soil, they fell within the acceptable limits for land application and is a suitable biochar resource, especially biochar produced at 450 _C had rich micropores, relatively stable functional groups in structure and rugged surface to contact well with soil, conducive to its usage as a biochar. The garlic grew faster when planted in the biochar-amended soil and had higher final dry matter yields than those planted in the reference soil, especially biochar produced at 450 _C corresponding to the highest final yields.

Application of biochar from sewage sludge to plant cultivation: Influence of pyrolysis temperature and biochar-to-soil ratio on yield and heavy metal accumulation

X.D. Song [a], X.Y. Xue [a], D.Z. Chen [a], P.J. He [b], X.H. Dai [c]
[a] Thermal & Environmental Engineering Institute, Tongji University, 200092 Shanghai, China
[b] State Key Laboratory of Pollution Control and Resource Reuse, College of Environmental Science and Engineering, Tongji University, 200092 Shanghai, China
[c] National Engineering Research Centre for Urban Pollution Control, College of Environmental Science and Engineering, Tongji University, 200092 Shanghai, China

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Our results indicate there is a great potential to convert wastewater sludge to biochar in order to improve the management of this waste, reduce its transport costs and reduce the production volume. Produced biochar may serve as a valuable soil amendment by supplying plant nutrients and other benefits including carbon sequestration. Our results further highlight the potential to improve the quality, hence the agronomic value and minimize the potential harmful effects of the biochars by controlling the pyrolysis temperature. It is especially very important to have a better understanding of the mobility and bioavailability of the trace elements present in the biochar, before field trials are attempted.

Phosphorus

The total P content in the wastewater biochar increased by 43% when pyrolysed at a temperature of 700 _C indicating phosphorus is associated with the inorganic fraction of the wastewater sludge (Fig. 2). This finding showed similar increasing trend to the reported increase of phosphorus with temperature from 5.6% at 250 _C to 12.8% at 800 _C in biochar produced from sewage sludge (Chan and Xu, 2009). Bridle and Pritchard (2004) also discussed the full recovery of P in biochar produced from sewage sludge at 450 _C.

Influence of pyrolysis temperature on production and nutrient properties of wastewater sludge biochar

Mustafa K. Hossain [a], Vladimir Strezov [a], K. Yin Chan [b], Artur Ziolkowski [a], Peter F. Nelson [a]
[a] Graduate School of the Environment, Faculty of Science, Macquarie University, NSW 2109, Australia

[b] NSW Industry and Investment, Locked Bag 4, Richmond, NSW 2753, Australia

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pH, BET surface area, porosity and total concentration of Cu, Ni, Zn, Cd and Pb increased with pyrolysis temperature from 400 to 600 ◦C, whereas cation exchange capacity and electrical conductivity of biochar decreased with respect to feedstock. These reductions are more important for biochar obtained at 600 ◦C. The volatile matter content of biochar decreased with the increment of pyrolysis temperature from 400 ◦C to 600 ◦C while the biochar fixed carbon content was similar at two pyrolysis temperatures. Differences on biochar properties significantly influenced their effect on soil properties after their amendment. Soil field capacity and available water increased after amendment with biochar obtained at 600 ◦C while differences were not observed in case of biochar obtained at 400 ◦C.

Physicochemical and agronomic properties of biochar from sewage sludge pyrolysed at different temperatures

A. Méndez [a], M. Terradillos [b], G. Gascó [b]
[a] Departamento de Ingeniería de Materiales, E.T.S.I. Minas, Universidad Politécnica de Madrid, C/Ríos Rosas n 21, 28003 Madrid, Spain
[b] Departamento de Edafología, E.T.S.I. Agrónomos, Universidad Politécnica de Madrid, Ciudad Universitaria, 28004 Madrid, Spain

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Heavy metals in this research mainly existed in inert form in biochar, indicated their availability to plants becoming lower after carbonization.

The Changes of Heavy Metals in Sewage Sludge Following Pyrolysis Treatment

Ma T; Song Y; Zhao X; Li G; Lin Q
College of Resource and Environment, China Agricultural University

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Sewage sludge biochar has the potential to be used in agricultural production to satisfy the needs of plant growth and serve as a fertilizer...Applying sewage sludge biochar to infertile and polluted soils promoted the plant growth and increased the fresh matter weight of Chinese cabbage. Heavy metals were not prone to bioaccumulation in the plant, and the plant availability of heavy metals was reduced in polluted soil.

The sewage sludge biochar can improve soil fertility and enhance plant growth while not increasing plant uptake of heavy metals, and remedy contaminated soil by reducing the plant availability of heavy metals.

Nutrients and Heavy Metals in Biochar Produced by Sewage Sludge Pyrolysis: Its Application in Soil Amendment

Taoze Liu [1], Bangyu Liu [2], Wei Zhang [2]

[1] State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences
[2] Geography and Tourism Department of Guizhou Normal College

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Flash pyrolysis can likely offer a valuable processing method for heavy metal contaminated biomass, thus limiting the waste disposal problem associated with phytoremediation.

Flash pyrolysis of heavy metal contaminated biomass from phytoremediation: Influence of temperature, entrained flow and wood/leaves blended pyrolysis on the behaviour of heavy metals

M. Stals[a], E. Thijssen[a], J. Vangronsveld[b], R. Carleer[a], S. Schreurs[c], J. Yperman[a]
[a] Lab of Applied and Analytical Chemistry, CMK, Hasselt University, Agoralaan Gebouw D, 3590 Diepenbeek, Belgium
[b] Lab of Environmental Biology, CMK, Hasselt University, Agoralaan Gebouw D, 3590 Diepenbeek, Belgium
[c] NuTeC, Dept. TIW, XIOS, Agoralaan Gebouw H, 3590 Diepenbeek, Belgium

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Researchers at the University of York say that more should be done to tackle the problem of inappropriate disposal of pharmaceutically-contaminated wastes. They also have a potential solution.

The technology relies on pyrolysis, a thermochemical decomposition process using high temperatures and an absence of oxygen, followed by catalytic conversion to clean and convert the gases. Seventeen of the most thermally stable pharmaceuticals were tested in the trial, which revealed that PyroPure® technology destroys over 99 per cent of 10 of the pharmaceuticals and an average of 94 per cent of the remaining seven.

Tackling pharmaceutical fall-out in the environment

Masters student Zoe Williamson carried out the survey under the supervision of Professor Alistair Boxall at the University of York in the UK.

The EWS AATS Thermolysis Solution

To appreciate why the Advanced Thermolysis System (ATS) is the best and to date the only system incorporating a solution for the organic waste problems that earlier and current pyrolysis systems encounter. To illustrate this new Technology, we will trace the development of earlier pyrolysis systems and the disadvantages each and the current pyrolysis systems encounter.

1) First Traditional Pyrolysis system (whether a batch system and its loading and unloading problems or a continuing system) just applied external heat into a sealed thermal chamber. This resulted in an extremely poor grade of bio char resulting from a poor penetration of bio mass. Other problems encountered were a tar build up in the piping system and poor heat control.

2) Subsequently, an upgraded Traditional Pyrolysis System (second Pyrolysis System) was required, which used a catalyst such as N2 to create a more thorough penetration of the bio mass feedstock, thereby releasing more of the volatiles from the biochar which created a purer carbon biochar with a higher surface area. But this had the following disadvantages: (a) Catalysts are expensive (b) did not solve the problem of tar build up in the piping (c) insertion of N2 into the thermal chamber lowered the processing temperature in the thermal chamber.

3) To overcome the difficulties encountered above, a further upgraded system was required. Some of the difficulties incurred in 2 were overcome by physical activation using steam injection into the thermal chamber at 100C+. This avoided the use of expensive catalysts and provided a more thorough penetration of the feedstock thereby releasing more of the volatiles, and addressing the problem of tar buildup, the quality of the by-products was not addressed. To overcome all of the technical difficulties incurred in the Pyrolysis systems referred to above, our Technical team headed by our Chief Scientist, developed the Advanced Activation Thermolysis System (AATS), which addressed all the above problems.

This was accomplished by incorporating a more advanced physical activation system incorporating the use of super-heated steam (temperature approx. 500C). Not only did our Technical team address this issue but they also engineered a novel way of creating this super-heated steam using the heated thermal chamber as a source for super heating the steam. Subsequently, further improvements were developed involving a thermal chamber containing 3 reactor tubes, each containing a rotating auger to ensure a thorough mixing of the feedstock. This new design significantly creates much more heat efficiency than the traditional large single tubular reactors.

The advantage of incorporating super-heated steam, since it was near the processing temperature of the thermal chamber, ensured that there was only a small drop in the processing temperature. This resulted in a temperature, near the equivalent, to what is required to create activated carbon, a high quality/price by-product from wood biomass. With the required and adjustable temperature, the ATS system can partially activate the biochar produced so that it approaches the quality of the desired grade of activated carbon (having a surface area approaching 140 to 500 square meters per gram of biochar depending upon the activation time).

Our technical team recognized that there was no singular process in the industry for activating bio char into activated carbon. To introduce such a revolutionary method, our technical team invented a state-of-the-art energy efficient design for an activation reactor for inclusion in our modified ATS system, and thereby, utilizing the extra heat generated (approx. 1000C), to transform biochar into activated carbon, a product that has a high value in the market.

We believe the Advanced Thermolysis System (ATS) and its innovative design incorporating other features such as a modified Venturi condenser, gravitational dust separator, 3 phase furnace, activation chamber (none of which are present in other current pyrolysis systems), delivers the best quality of biochar or activated carbon achievable in the present market.

The bottom line is this:

Sewage sludge spread on land is a public health danger, it is a burgeoning legal quagmire, pyrolysis is the best alternative to dealing with it and the AATS technology from Emergent Waste Solutions is the leading pyrolysis solution in the market today.