The Influence of Soil on Public Health

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Abstract
Soil is the most complicated biomaterial on the planet due to complex soil architecture and billions of soil microbes with extreme biotic diversity. Soil is potentially a source of human pathogens, which can be defined as geo-indigenous, geo-transportable, or geo-treatable. Such pathogens cumulatively can and do result in multiple human fatalities annually. A striking example is Helminths, with current infections worldwide estimated to be around two billion. However, soil can also be a source of antibiotics and other natural products that enhance human health. Soil-borne antibiotics are used to treat human infections, but can also result in antibiotic-resistant bacteria. Natural products isolated from soil resulted in 60% of new cancer drugs between the period 1983-1994. Soils are also crucial to human health through their impact on human nutrition. Finally, from a global perspective, soils are vital to the future well-being of nations through their impact on climate change and global warming. A critical review of soil with respect to public health leads to the conclusion that overall soil is a public health saviour. The value of soil using a systems approach is estimated to be $20 trillion, and is by far the most valuable ecosystem in the world

Key Words
Soil, pathogens, antibiotics, natural products, carbon sequestration.

Introduction

Soil is usually thought of as dirt by the layman or material that you walk on, or something that gets all over you. When we move to the higher echelon of science, researchers usually think of soil from the agronomic aspect, or perhaps in terms of its environmental influences. What is generally not recognized is that soil can have both direct and indirect influences on public health, and that these effects can be beneficial or harmful. In this paper we discuss whether or not soil is a public health threat or saviour.

Soil as a public health threat or saviour

Soil as the earth's veneer

Soil takes thousands of years to develop and can be as thin as 1 meter or as thick as 30 meters. This fragile veneer is the most complicated biomaterial on the planet, and is vital for human life as we know it (Young and Crawford 2004). Abiotic soil constituents such as sand, silt, clay and organic colloids control the chemical transformations that occur via surface mediated reactions. Conversely trillions of soil microorganism control biochemical transformations within soil. Soil microbes can also infect humans causing disease, or be a source of toxins. Microbes can also be a source of natural products that benefit human health.

Table 1. Direct influences of soil on public health.

Antibiotic resistant microbes within soil	Soil microbial production of antibiotics, e.g., Streptomycin
Soil toxins, e.g., aflotoxin	Natural products, e.g., paclitaxel
Plant pathogens, e.g., *Fusarium*	Soil microbes enhancing plant growth, e.g., *Pseudomonas*

As seen in Table 1 soil can directly influence public health in a positive or detrimental manner. Soils can be a source of various types of pathogens (Table 2). Soils can even be a potential source of death as in the case of geoindigenous pathogens (Table 3) or provide substances that save lives as in the case of the anti-cancer agent paclitaxel (Table 4).

Table 2. Soils and human pathogens.

Geo-indigenous soil pathogens • Human pathogens native to soils that can metabolize and reproduce
Geo-transposable soil pathogens • Soil enhanced transport of pathogens via water or dust
Geo-treatable soil pathogens • Inactivation of introduced pathogens by soil

Adapted from Pepper *et al.* 2009.

Table 3. Human geo-indigenous soil pathogens.

Type of organism	Affliction	Incidence in soil
Human virus	NA	Never indigenous-no host
Bacteria		Routinely found in most soils
Bacillus anthracis	Anthrax	Found in soil composts and potting soil
Legionella spp.	Legionnaire's disease	
Fungi		
Coccidiodes immitis	Valley Fever	Highly prevalent in SW United States
Histoplasma capsulatum	Respiratory infections	Prevalent in Midwest and southern United States
Protozoa		
Naegleria fowleri	Brain encephalitis	Found in soil and water

Adapted from Pepper *et al.* 2009.

Table 4. Impact of natural products on human health.

Item	Extent %	Reference
Prescription drugs	40	Strobel and Daisey 2003
New chemical products registered by U.S. Food and Drug Administration	49	Brewer 2000
Approved drugs between 1989 and 1995	60	Grabley and Thiericke 1999
Approved cancer drugs between 1983 and 1994	60	Concepcion *et al*. 2001
Approved antibacterial agents between 1983 and 1994	78	Conception *et al*. 2001

Adapted from Pepper *et al*. 2009.

On balance however, the overall direct impacts of soil on public health are beneficial, as evidenced by food itself which is grown in soil and sustains the world's population. Soil is also a large reservoir of natural products and antibiotics that save millions of lives.

Soils can also affect public health indirectly through their effect on climate change. Specifically global climate change is now predicted to result in catastrophic events including tsunamis, flooding, droughts, and changes in the regions of the world that become inflicted with microbial infectious disease. Soils constitute the single largest terrestrial carbon stock, with more than three times that in vegetation and function as both a source and a sink of carbon dioxide (CO_2) Managing soils to increase soil organic carbon (SOC) storage and remove CO_2 from the atmosphere provides a significant, immediately available, low-cost option for mitigating GHG emissions (Paustian *et al.* 1998; Lal 2004). Improved crop and soil management strategies have the technical potential to sequester as much as 200 Tg CO_2/yr in the US (~15% of US emissions) (CAST 2004) and 5000 Tg CO_2/yr, globally (IPCC 2007). Overall, amount of C stored in soils is a function of biological, chemical, and physical parameters (Rice and Angle 2004). .

Conclusions

A critical review of soil with respect to public health leads to the conclusion that soil is a public health saviour. The number of soilborne geo-indigenous human pathogens is far less the number of pathogens that are introduced into soil and subsequently inactivated. More importantly, soils possibly impact human health and welfare in other profound ways. Sickness and ill health are routinely treated with natural products

obtained from soils, such as antibiotics, anti-cancer drugs, insult mimics, and immunosuppressive drugs. In addition, soils provide food and nutrition for humans and animals alike. Attempts have recently been made to estimate the value of ecosystems using the "global unified metamodel of the biosphere" (GUMBO). Using this systems approach, soil was estimated to have a global value of $20 trillion, and is by far the most valuable ecosystems in the world (Boumans *et al.* 2002). However, in light of the enormous beneficial influences of soil on public health, even this dollar value is likely to underestimate the true value of soil by several orders of magnitude. Indeed, life on Earth without earth would be impossible.

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