



## Monday Morning Plenary

Item Type	event;event
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Download date	2026-06-08 08:47:02
Link to Item	<a href="https://hdl.handle.net/20.500.14394/3655">https://hdl.handle.net/20.500.14394/3655</a>

# The 19<sup>th</sup> Century Roots of Biochar – A History



By Kelpie Wilson

# Biochar in the 19<sup>th</sup> Century



- œ The role of agricultural chemist Justus Liebig
- œ 19<sup>th</sup> century “bloggers” spread the charcoal meme
- œ Charcoal in a campaign to save the starving Irish
- œ Charcoal and the London Sewage Question
- œ Charcoal and food security
- œ Some Final Questions

# Justus von Liebig

1803 - 1873



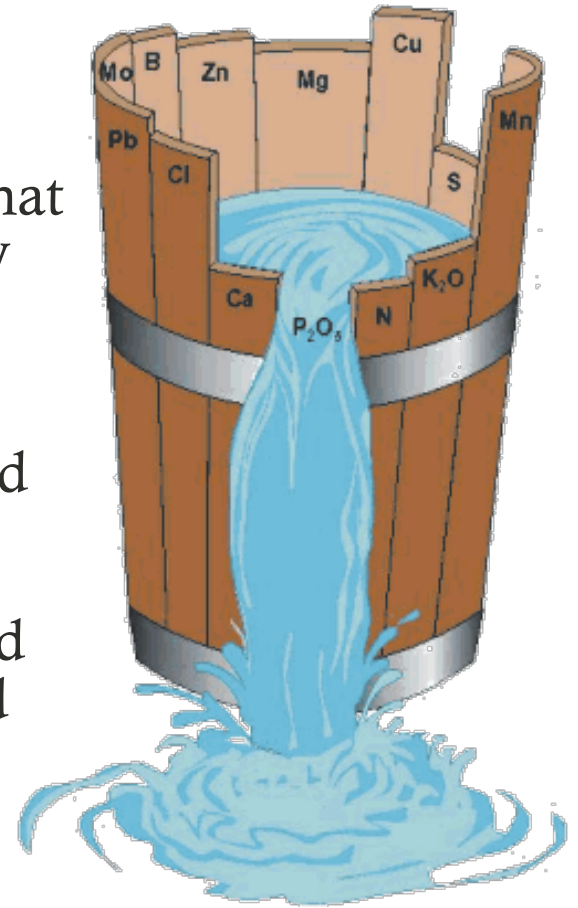
- Justus Liebig is recognized as one of the first genuine experimental chemists. At a young age, he established a laboratory at Giessen that was the envy of Europe.



# Beginnings of Chemical Agriculture



- ☞ Through his experimental work, Liebig established the "law of the minimum," that states that plant growth is constrained by the least available nutrient in the soil.
- ☞ These discoveries spurred a growing fertilizer industry that mined and shipped huge amounts of guano, bonemeal, lime and other fertilizers from all parts of the world to fertilize the fields of Europe and eliminate the need for crop rotations and fallow periods to replenish the soil.



# Vitalism or Physical Determinism?



- ✧ In Liebig's time, the chemical approach to agriculture was new. The prevailing theories invoked the principle of vitalism.
- ✧ Vitalism: A doctrine that the functions of a living organism are due to a vital principle distinct from physicochemical forces.
- ✧ Believers in vitalism thought that black soil contained an organic life force or "vitalism" that could not be derived from dead, inorganic chemicals. This theory was based on the well-known fact that "virgin" soil from recently cleared forests was black and fertile. Early chemists extracted this black substance and called it "humus".

# Was vitalism a relic of ancient religion?



The Greek Goddess Gaia – Goddess of the Fertile Earth

Black Virgin images found in churches throughout Europe may represent the vital principle of the black soil.



Did the Humus Theory arise out of these ancient ideas?

# How Liebig disproved the Humus Theory



- ∞ Some chemists proposed that plants needed humus as a source of carbon, but Liebig showed that humus was too insoluble to provide the needed carbon. And besides, plants can grow in pure charcoal.
- ∞ Charcoal is even more recalcitrant than humus. Liebig concluded that a plant that grows in charcoal must get its carbon from carbon dioxide in the air.



# Humus, reconsidered, and charcoal too.



- ☞ Liebig soon realized that humus did have a very important function in soil - it could absorb and hold chemical fertilizers that would otherwise leach away before plant roots could take them up. He compared the absorptivity of humus to that of charcoal.
- ☞ He also wrote that charcoal "surpasses all other substances in the power which it possesses of condensing ammonia within its pores... it absorbs 90 times its volume of ammoniacal gas, which may be again separated by simply moistening it with water." (*Agricultural Chemistry*, p 35.)

# 19<sup>th</sup> Century Bloggers



- ❧ A search of Google Books will yield hundreds of articles from 19<sup>th</sup> century agriculture and gardening journals on the benefits of charcoal. Most are free to read online.
- ❧ Many of the articles are “re-posts” – copies of articles that appeared in other journals.
- ❧ Many articles consists of comments on earlier articles and testimonials about the farmer’s experiences with charcoal.

# Hot new idea for the hothouse



Liebig publicized a series of hothouse experiments using mixtures of charcoal in potted plants that gave fantastic results:

- ❧ "An addition of charcoal, for example, to vegetable mould, appeared to answer excellently for the *Gesneria* and *Gloxinia* and also for the tropical *Aroideae* with tuberous roots. These soon excited the attention of connoisseurs, by the great beauty of all their parts and their general appearance."
- ❧ "Pure charcoal acts excellently as a means of curing unhealthy plants. A *Doriantes excelsa*, for example, which had been drooping for three years, was rendered completely healthy in a very short time by this means... The same was the case with the Gardenia."

# Educated hobbyists were the early adopters



- ❧ “My attention was first drawn to the influence of charcoal, by the wonderful experiments of Baron von Liebig, in the propagation of plants, and the facility with which cuttings were rooted in this substance. Its use became very general in Europe by amateurs and cultivators of plants... (The Horticulturist, 1869)



# Some Quotes:

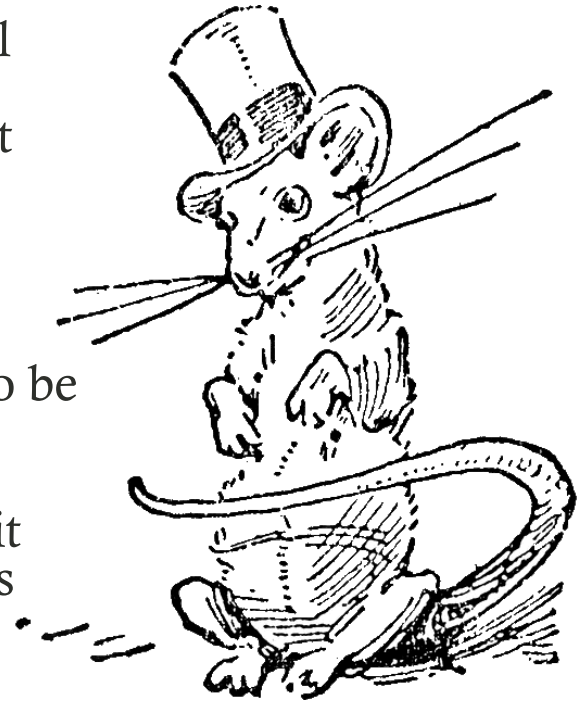


- ☞ “For two years past I have used some fifty loads each season of refuse charcoal, and being fully convinced that it pays, I wish to recommend it to my brother farmers... Applied to half an acre of early potatoes the last summer, the yield was 75 bushels of as fine healthy potatoes as could be desired, that sold readily for one dollar per bushel, and yielded the best profit of anything raised on the farm.” (The New Jersey Farmer, 1856)
- ☞ “In the midst of the disastrous drought of last summer, while crossing a field in Moriah... I observed a lot with its surface deeply and singularly blackened. Upon inspection I found it thickly strewn with pulverized charcoal. The field presented a rich verdure, strongly contrasting with the parched and blighted aspect of the adjacent country.” (New York State Agricultural Society, 1853)

# More Quotes:



- ❧ “Poudrette (night-soil deodorized with charcoal dust) is one of the best manures for the rose... Charcoal dust is an excellent surface dressing; it imbibes and retains moisture, keeps the plant healthy and intensifies the color of red varieties.” (Turner, 2012, p. 72)
  
- ❧ “A dead rat, nicely buried in a cigar box so as to be surrounded at all points by an inch of charcoal powder, decays to bone and fur without manifesting any odour of putrefaction, so that it might stand on a parlour table and not reveal its contents to the most sensitive nostrils.” (The Garden, 1873)



# Then, as Now....

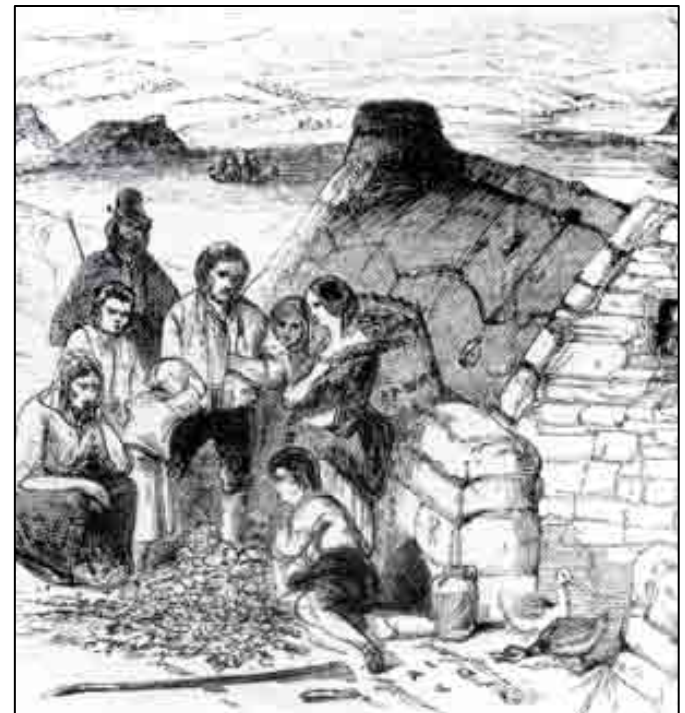


- ❧ “Most persons are perfectly familiar with the effects of charcoal upon vegetation. The great desideratum is how to obtain it in quantities, and at a rate to make it an object in husbandry.”
- ❧ “The use of charcoal as a fertilizer is generally well known. Its expense, however, often precludes its use.”
- ❧ “I must regret the high price that the manufacturers... have imposed upon their article, and which amounts to almost a prohibition of its use in the great way.”

# Peat Charcoal and the Irish Famine



- ✎ Jasper Wheeler Rogers, Irish engineer and humanitarian, thought peat charcoal could serve as a cheaper source of agricultural charcoal and also address the Irish famine.
- ✎ Rogers envisioned an industry that would pay cash wages for converting Ireland's peat to charcoal. Workers would have money to buy food, and the peat charcoal would clean up the filth of Dublin and London while providing a valuable fertilizer.

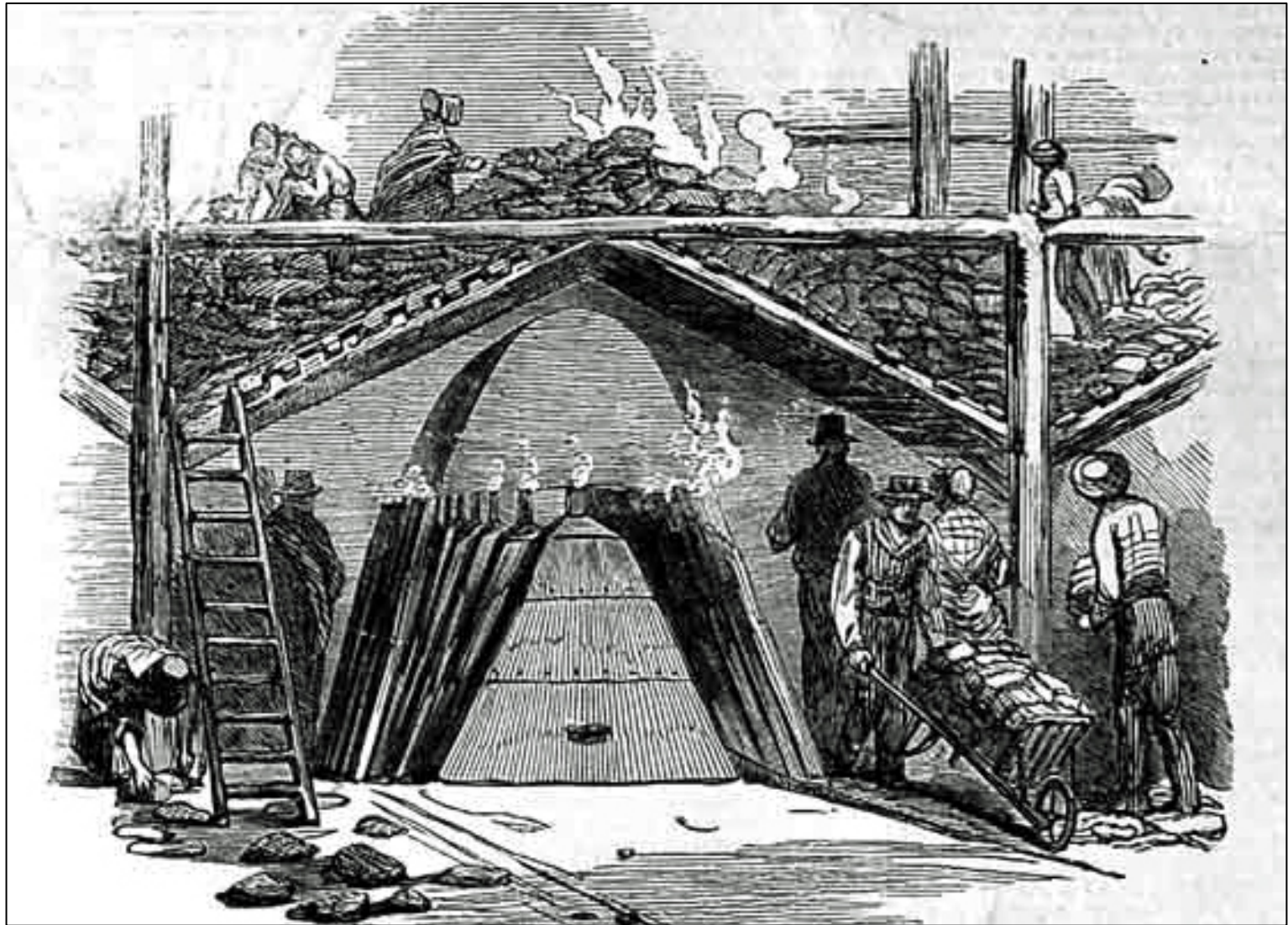


# The Irish Amelioration Society



Jasper Wheeler Rogers raised money for his cause from wealthy members of society.

# Peat charcoal works at Derrymullen, 1850



# The Sewerage Question



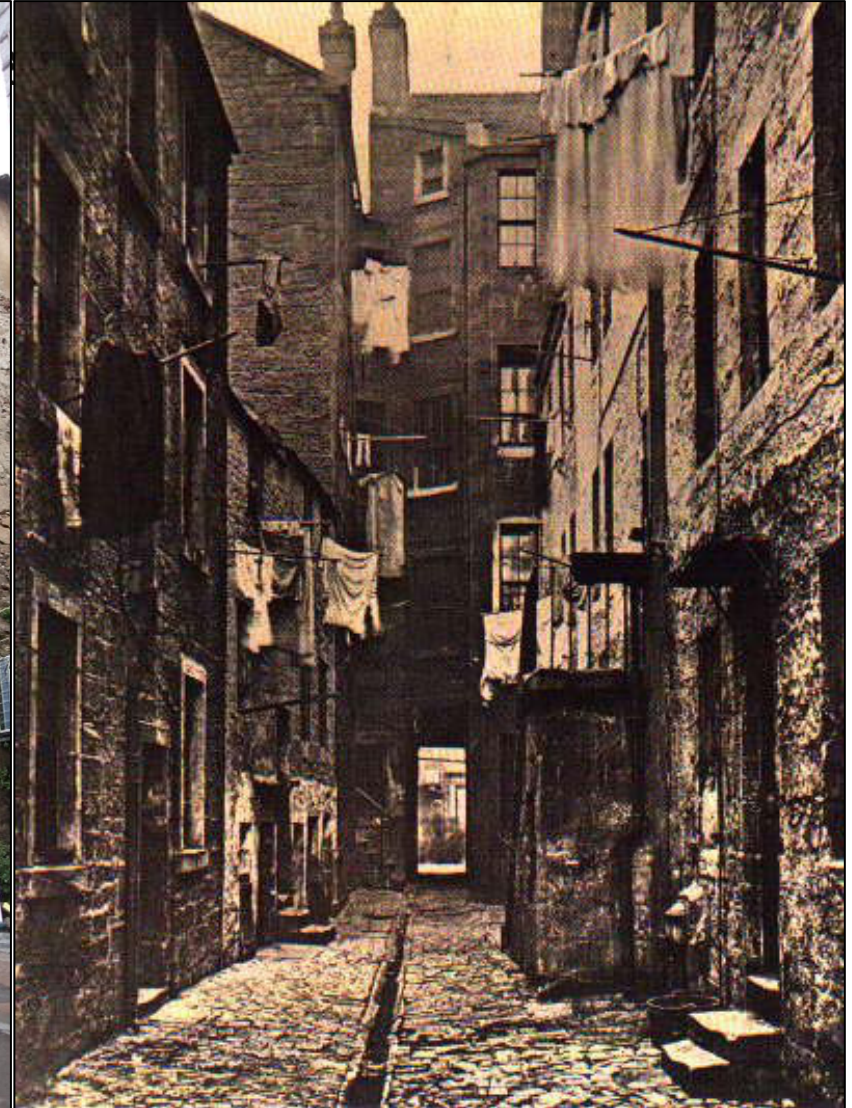
☞ "The problem for the engineer to solve is, how can 3,000 tons of town guano be returned daily to the disinfecting soil, from which it was chiefly taken, with the least offense to health and with the least cost? Shall it be distributed by pipes or by railways? Shall it be disinfected by water, earth, ashes or any chemical compound? Under the present arrangements some hundreds of thousands of tons of this matter lie in store in London, putrefying in cesspools, and percolating the streets, while the residue is thrown into the Thames at great cost."

-- *Jasper Wheeler Rogers, Facts and fallacies of the sewerage system of London, and other large towns (1858)*

# The Great London Stink, 1858



# The Irresistible Flush



# Liebig's concern with food security



- ☞ Liebig thought that flushing town sewage to the sea was a waste of nutrients that would have serious consequences some day.
- ☞ Despite his role in building the chemical fertilizer industry, Liebig had misgivings about the importation of fertilizers and the consequences for food security: "in the event of war with America when supplies of guano would cease."

**SOLUBLE PACIFIC  
GUANO**

FOR

**CORN**  
**POTATOES**  
**TOBACCO**  
**GRASS**

**ROOT**  
AND  
**GRAIN CROPS**  
Of all kinds  
**GARDEN  
VEGETABLES**  
&c., &c.

ITS USE SECURES TO THE FARMER A  
**LARGE AND REMUNERATIVE CROP,**  
And has been found to pay better than any other investment.

FOR PARTICULARS CALL ON

The advertisement features a central illustration of a penguin standing on a large bag of fertilizer labeled 'SOLUBLE PACIFIC GUANO'. The penguin is holding a small fish in its beak. The background shows a seascape with waves and birds flying in the sky. The text is arranged in a structured, bold font, with the product name at the top and a list of crops on the left and right sides. At the bottom, there is a testimonial-style statement and a call to action.

# How it was done before the flusher



# Poudrette, the genuine article



“There is no doubt as to the great value of a good article of poudrette. We make it by mixing with the night soil, copperas, charcoal and muck. When thus made, it is a very powerful fertilizer. But the poudrette of commerce is of very doubtful character. I had purchased some, and found it nothing more than the sweepings of blacksmith shops; or horse droppings, mingled with dust and dirt. Such poudrette was of no account.” (New York State Agricultural Society, 1868)

## **TO FARMERS.**

### **POUDRETTE! POUDRETTE!!**

The LODI MANUFACTURING COMPANY (the oldest manufacturers of Fertilizers in the United States) offer their celebrated Poudrette for sale at lower prices than any other fertilizer in market.

It is made from the night soil and offal of New York City, and has been in use by thousands of farmers for over a quarter of a century: \$4 will manure an Acre of Corn in the hill, and increase the yield one third.

A Pamphlet with the experience in its use on Lawns, Garden Vegetables, Corn, Potatoes, and Tobacco, of hundreds of Farmers, some of whom have used it for over 20 years, containing also price, directions for use, &c., will be sent *free* to any person applying.

**LODI MANUFACTURING CO.,**

66 Courtlandt Street, New York.

# Liebig's Criticism



- ☞ Liebig acknowledged the efforts in many European cities to manufacture fertilizers from human waste but found that "the manner in which this is done is the most injudicious which could be conceived."
- ☞ "In Paris, for example, the excrements are preserved in the houses in open casks, from which they are collected and placed in deep pits ... but are not sold until they have attained a certain degree of dryness by evaporation in the air. But whilst lying in the receptacles ... the greatest part of their urea is converted into carbonate of ammonia... and the vegetable matters contained in them putrefy; all their sulphates are decomposed... The mass ... has lost more than half of the nitrogen, which the excrements originally contained."

# Liebig's Recipe



- ∞ Liebig recommended, “calcined mud and finely divided charcoal” (*Agricultural Chemistry*, p 66) as additives that would effectively retain the nitrogen.
- ∞ He also advised a manufacturer on a patented formulation that included "soot, wood charcoal, seaweed charcoal, animal charcoal, or phosphate of lime, sulphates of manganese and of iron."

# Liebig on China



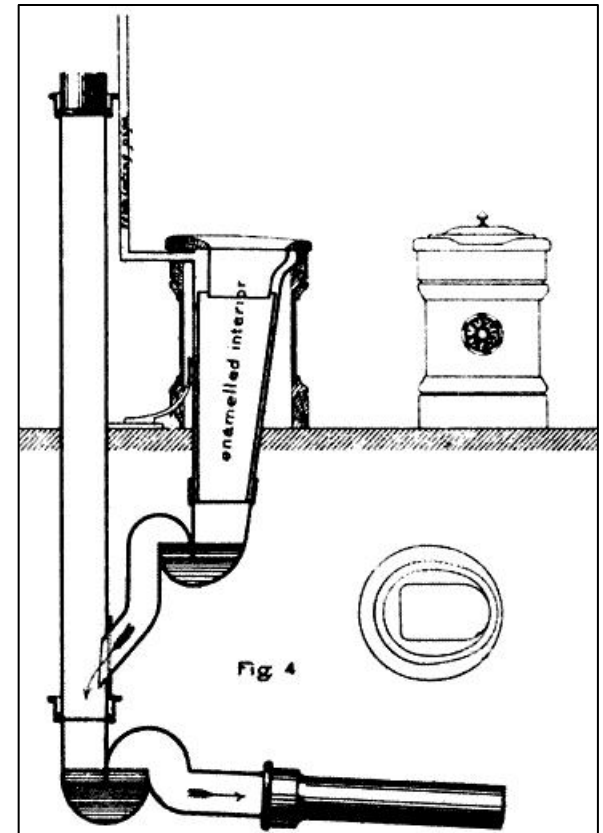
- ☞ “The Chinese are the most admirable gardeners and trainers of plants...the agriculture of their country is the most perfect in the world.”
- ☞ Perfect because the Chinese understood the importance of the "most important of all manures," human excrement.
- ☞ But the Chinese did not routinely use charcoal to preserve the human wastes. Instead, they employed a large work force to quickly move the waste to the countryside.



# What happened at Derrymullen



- ❧ In 1853, Jasper Wheeler Rogers landed in debtor's prison in London, his estates and effects confiscated, the kilns at Derrymullen shut down.
- ❧ Still, by 1858 he was back promoting his ideas, trying to win the day for charcoal sanitation. He issued a patent for a pneumatic toilet that would move the contents of dry closets and mix them with peat charcoal.



# Another loss for charcoal



- ❧ For his part, Liebig tried very hard to lobby decision makers in London about the wastage of valuable nutrients in sewage, to no avail.
- ❧ By 1876, a report to Parliament came down firmly on the side of hydraulic sewage systems. They concluded: "none of the manufactured manures made by manipulating town's refuse with or without chemicals, pay the contingent costs of such modes of treatment." (Local Government Board, 1876, p xii)

# The Future of Biochar?



- ❧ Biochar made sense to a lot of people in the 19<sup>th</sup> century, but it was not the cheapest way to do things.
- ❧ Today's agriculture is still based on Liebig's chemical principles.
- ❧ But things are changing. We now know that we need both life and carbon in the soil.
- ❧ We also have a climate crisis.
- ❧ In the future, our attitude may change from: "Get your carbon out of my atmosphere" to "Help me get that carbon back in my soil."

# A New Vitalism?



- Liebig once started an argument with Pasteur over fermentation, asserting that vinegar was produced by chemical action, not by life forms. When Pasteur proved that vinegar was produced by microorganisms, Liebig conceded. That's how science works.
- Today, we know that soil is much more than inert chemicals. It is packed full of life essential for the growth and health of our food plants. In a sense, we have returned to the “Vital” principle of agriculture.

# A Final Question



- ☞ On his deathbed in 1873, Liebig ordered his coffin and directed that "his body should be packed in charcoal and buried in Darmstadt."
- ☞ Question: Why did Liebig have himself buried in charcoal?



# Thank You



- Thank you to the Ithaka Journal for publishing my article: [Justus von Liebig and the Birth of Modern Biochar](#)
- And thanks to the [Washington Department of Ecology](#) for sponsoring much of my research on 19<sup>th</sup> century biochar for a forthcoming publication: *Odor in Commercial Scale Compost: Literature Review and Critical Analysis*

I welcome your comments and questions!



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