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Wastewater, the Future of Power in Leicester's Homes

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Abstract
Sewage poses a pollution problem because it is in constant production. The solution lies in its conversion into a resource and on the assumption of daily production, sewage energy has the potential of becoming a supplement to Leicester's energy portfolio. Sewage energy can be maximised sustainably in several ways, while also pushing the city it supplies closer to being carbon neutral. This paper explores the possibility of sewage being used to power the households in Leicester, considering its population.

Keywords: Sustainability; Biology; Physics; Power-Energy; Biomass Processing; Alternative Power

Introduction
Sewage (wastewater) has become a plague because proper disposal is not adhered to, and there is pollution. Even in cases of proper storage, it is not sustainable. Over the years technologies have been created to utilize waste overflow by further processing to produce useful resources. A good example of this is the use of sewage for power generation. As far back as 19th century London, streetlamps were invented which was dually powered, i.e., these lamps made use of gas and sewage waste for power [1]. These technologies have since evolved to where cities now use sewage energy to supplement their electricity [2], vehicles run on sewage fuels [3], water plants are being powered by sewage energy [4] etc. The energy capabililities of sewage are exploited using methane gas anaerobic digesters [5], microbial fuel cells [6], plasma biosolids processed into syngas [7], or hollowed pico-hydraulic turbine [8] amongst others.

This sewage constitutes all biodegradable waste, both solid and liquid, human [1] and animal [9], household and industrial etc., which when processed forms biosolids (sludge) [7]. This paper will focus on organic matter in wastewater and its potential to power the city of Leicester's homes.

Power Generation via Sewage Production.
A $100W$ light bulb running continuously uses 2×10^6 calories a day, using the calories $(1000\ cal = 1\ kcal)$ to Watts conversion, but the world's food supply being used for energy while people still suffer from hunger is not feasible. In considering the organic matter in domestic wastewater, when processed an individual's waste can produce $\sim 25\ W$ (this is a daily assumption) and that is the same amount required to power a compact fluorescent bulb [5]. On an individual basis, it is insignificant but with a town of 10,000 people, their organic matter would be equivalent to 2.3 megawatts [5]. Only 10% of this power is required to make an average wastewater treatment facility carbon neutral [5]. But on a city-wide scale 2.3 megawatts is not a lot. As of 2014, between the thousands of waste treatment facilities in America, 10million tonnes of sludge was produced yearly. Sewage power generation could create about 1800 GWh of clean energy capable of covering ~0.5% of the national electricity consumption [7]. Asides electricity, there are other resources that could be produced like ethanol, hydrogen gas or other transportable fuels [5].

In a UK household energy survey, a typical household consumes over 2900 kWh annually. This survey was done across different households with electric heating, without electric heating and with additional electric heating [10]. The 2021 census of Leicester revealed a population of around 368,600 people, and with ~25 W per person, the organic matter in Leicester sewage can produce:

$$368{,}600 \times 25 \quad = 9{,}215{,}000\ W\ daily$$
$$= 9{,}215\ kW\ daily$$

On the assumption that this is the daily approximate, this calculation is fairly optimistic, especially considering that an average domestic consumption in Leicester is 3,598 kWh, when looking at consumption per meter [11].

Maximizing the Supply

Human waste is always in supply but, abundance is the issue. One of the ways this can be tackled can be by supplementing human waste with other forms of waste, and this is already a given because sewers contain both human and household organic matter, in its wastewater. An improvement would be, blending the sludge with other waste materials probably industrial waste that have some heating value such as hydraulic liquids, grounded coal, glycerol, etc. [7].

Another initiative towards maximizing sewage supply is to not just make use of the central collection point in one city, but to create a central treatment plant between cities. England's center being in Fenny Drayton in Leicestershire [12] and being only a 32 minute drive from Leicester, which is coincidentally the center of Leicestershire [13], Leicester's Wanlip and Severn Trent treatment plants could be expanded and the neighboring counties i.e., Nottinghamshire, Lincolnshire, Rutland, Northamptonshire, Warwickshire, Staffordshire, and Derbyshire [14], could supply their sewage and it can be used in Leicester. Furthermore, Leicester's present power capabilities supplemented by sewage power could be distributed across the supplying neighbors, making more power available and reducing the cost of electricity, in their counties. The constructional logistics would be an extensive and expensive project, but in the meantime, they could transport their sewage in tankers to the central treatment plant. This can then be enough sewage to generate power enough for Leicester's homes. A downside to this project may be Leicester's status as the center for integrated living in Leicestershire [15].

City	Population
Leicestershire	712,300
Nottinghamshire	824,800
Lincolnshire	769,474
Rutland	41,000
Northamptonshire	785,200
Warwickshire	148,500
Staffordshire	876,100
Derbyshire	71,500
TOTAL	$\mathbf{4,228,874}\ people$
With $\sim 25\ W$ per person	
$4{,}228{,}874 \times 25 = \sim 105{,}721{,}850\ W$	
In kW	$\mathbf{105,721.85\ kW}\ daily$

Table 1 – Leicestershire and the neighbouring counties with their population as of the 2021 census [16].

So, a counter argument can be that, as the population increases so does the sewage. Citizens could also be rewarded for volume of organic waste produced per household. The power generated may not seem like much but considering the daily assumption of ~25 W did not account for the sewage in grams required to produce the 25 W, the power generated per person could be a lot more.

Conclusion

Sewage power generation is not a 21st century innovation, yet not a lot has been done towards its advancement. The statistics upon a daily assumption show that in a day Leicester can produce d decent amount of energy that could serve as an addition Leicester energy portfolio and considering the suggestion of blending with other substances of heating value, the amount of energy produced could increase greatly. Leicester being the center of integrated living, also makes it the center of vehicle carbon emissions, because as people flood in, they come with their cars, public transports are busier, and emissions rise. Sewage energy has the potential to be an excellent supplement to Leicester's energy portfolio and as advancements progress, it can become a readily available alternative.

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