USING SFDS TO MONITOR EMISSIONS OF GHG IN WASTEWATER

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INTRODUCTION

The greenhouse gas emission from the treatment of water has recently become a popular topic in research. There are multiple studies on its effects and causes, but no structured analysis to integrate them. Through SFDs I propose a clear way to visualize the impact of water treatment on the environment and raise awareness.

My project is structured in two steps: researching previous studies while gathering data, and creating the SFDs on a picked scenario in order to generalize. The careful analysis of previous research is crucial in providing realistic and meaningful diagrams. a little bit of body text.

Background and research

The past decade has been deemed as the warmest one so far at a more than 1.1 C increase compared to the preindustrial era and the increase is accelerated at 0.2C per decade due to greenhouse gases. The main gasses that contribute to global warming are:

- Carbon Dioxide -is the leading contributor to GHG representing 79% of them and is mainly created by burning hydrocarbons
- Methane – less frequent than carbon dioxide and with a shorter lifespan in the atmosphere, it is 80 times more potent.
- Nitrogen Oxide- being 300 times more potent than carbon dioxide and with an average lifespan of 114 years, it is mainly emitted through agricultural processes and wastewater treatment.

A significant cause of GHG emissions is water treatment and sanitation. It causes 1.57% of the world's total yearly GHG and 5% of the total non-carbon dioxide emissions. It contributes to GHG directly through the breakdown of faecal matter in the environment and during the treatment process and indirectly through all the energy required in the three steps of water treatment: containment, transport and treatment.

When faecal sludge or wastewater is held for sufficient time to allow microbial digestion, faecal sludge or wastewater produces greenhouse gases (GHGs) including methane (CH4), Nitrogen oxide (N2O), and carbon dioxide (CO2). During the operation of sanitation operations and as part of the infrastructure, indirect emissions occur due to the burning of fossil fuels. In the sanitation sector, emissions are greatly understated.

Better monitoring technologies to better quantify emissions are the desired outcome. This data can then be used to inform treatment changes and optimize existing systems to reduce emissions. These measures have the potential to reduce CH4 and N2O emissions from current wastewater treatment plant configurations.

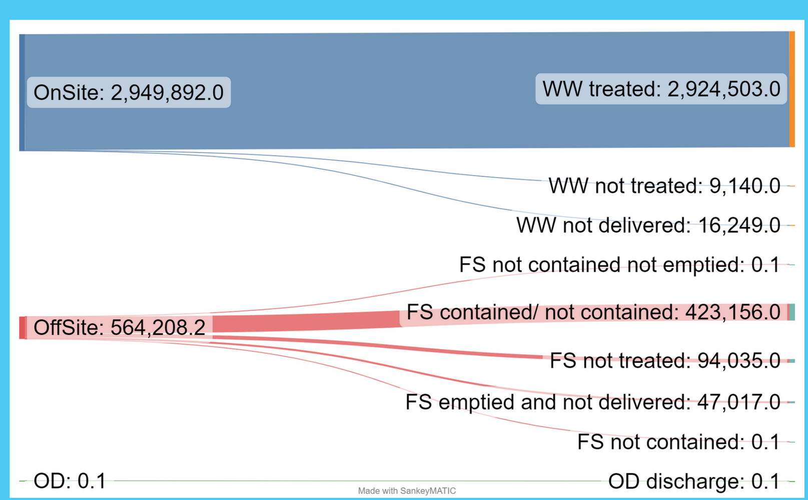
METHODS

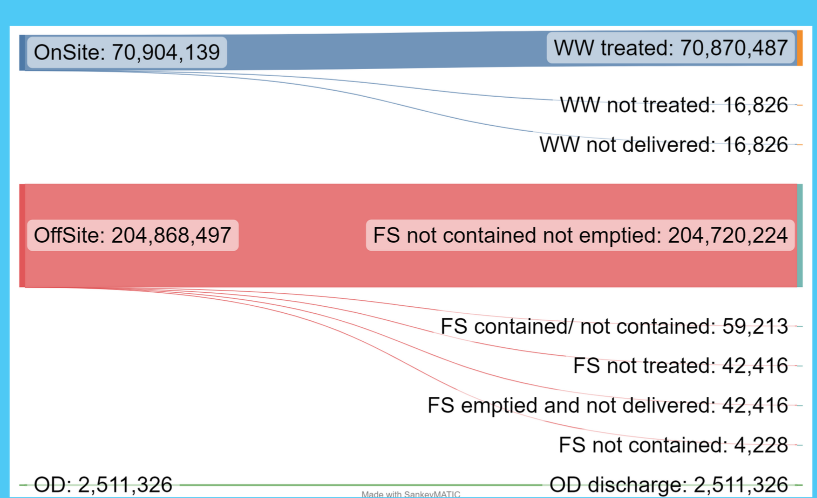
In the following project, SFDs have been taken of different cities. Using formulas derived in [1,2] the amount of gases from each source has been computed and drawn on the graphs below. The formulas used are presented below:

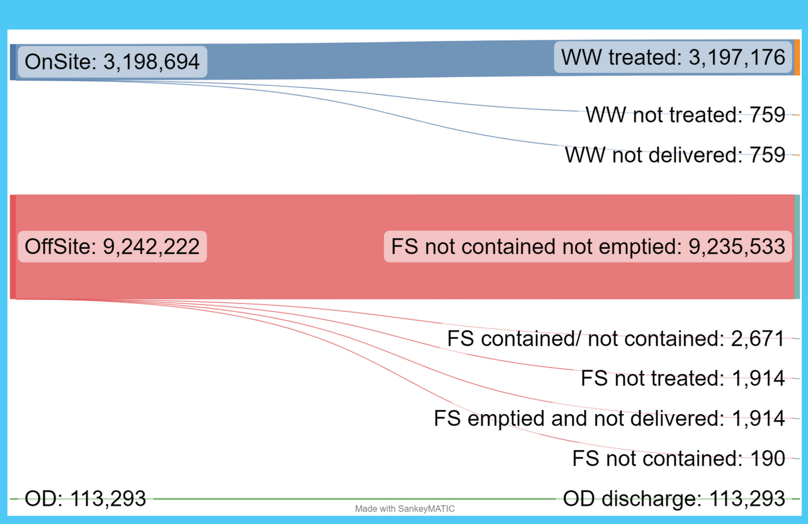
- The operational cost of treatment plants is computed as a linear regression of their energy usage as CO2 = Σ C x E, where C is the energy consumption, E is the energy factor which translates the source of energy to emissions.
- Methane emissions from treatment plants were calculated using a modified IPCC formula that is based on Reid et al. CH4=ΣU x EF x TOWx(1-(L+S+R) where U is the effective population EF is the emission factor, B0 is the maximum methane producing capacity kg CH4/kg COD by process in the local context TOW is total organics in wastewater per year, L is proportion of effluent, S is proportion of sludge, R is proportion of methane captured
- Nitrogen oxide emissions are calculated based on N2O=ΣP x NI x EFx(44/ 28) where P represents population, NI is nitrogen influent from urine and faeces, and EF is the emission factor factor.

RESULTS

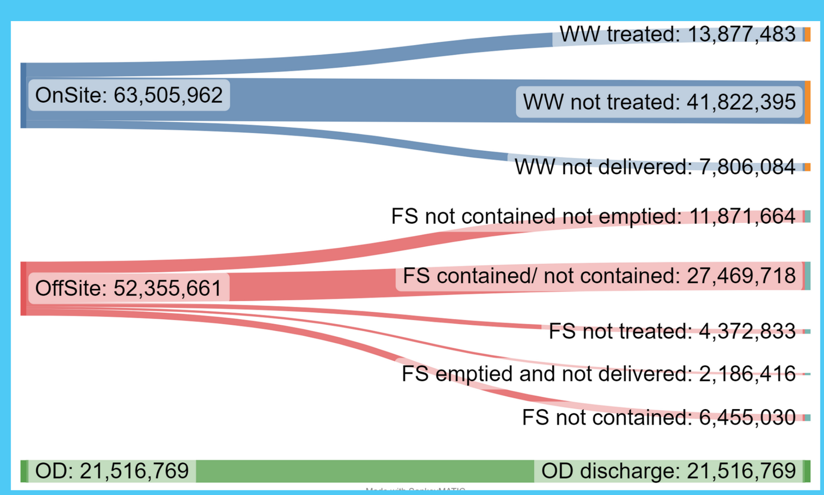
CH4

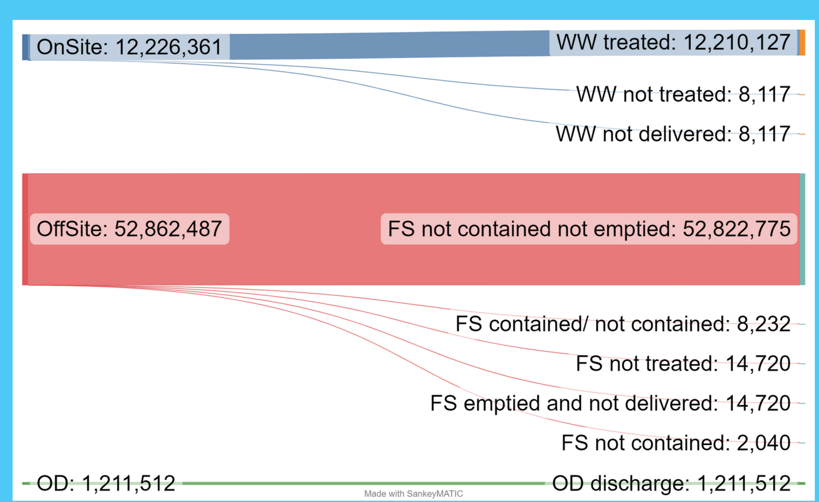


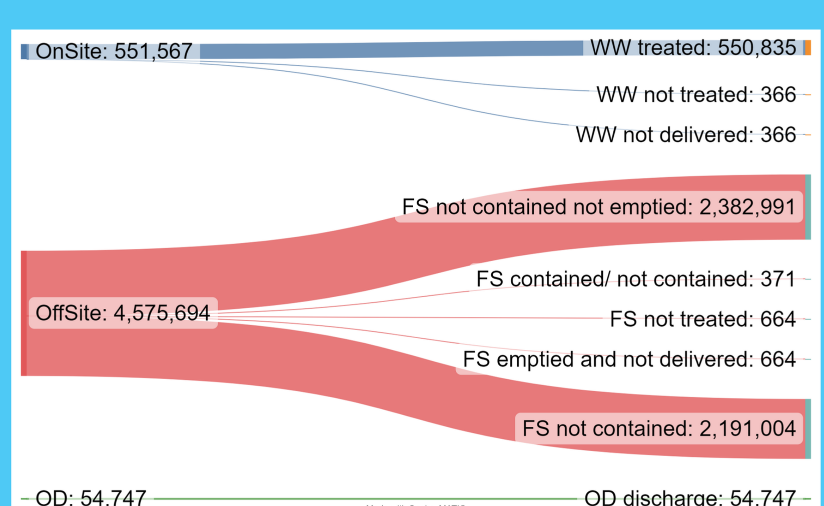




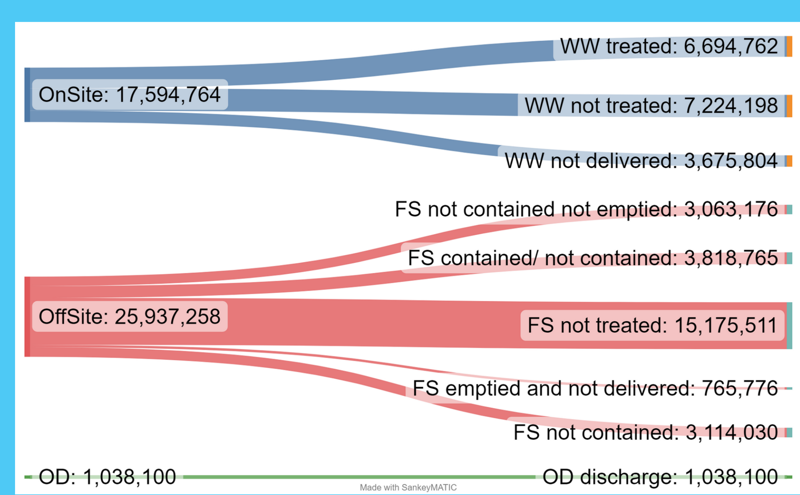
NO2

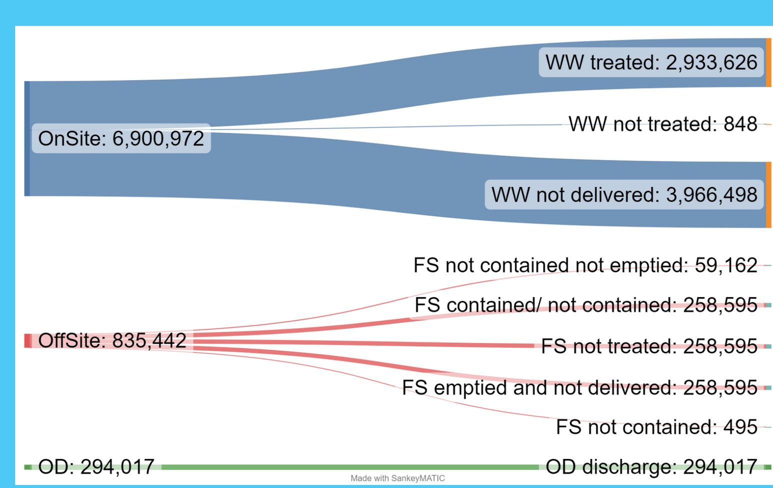


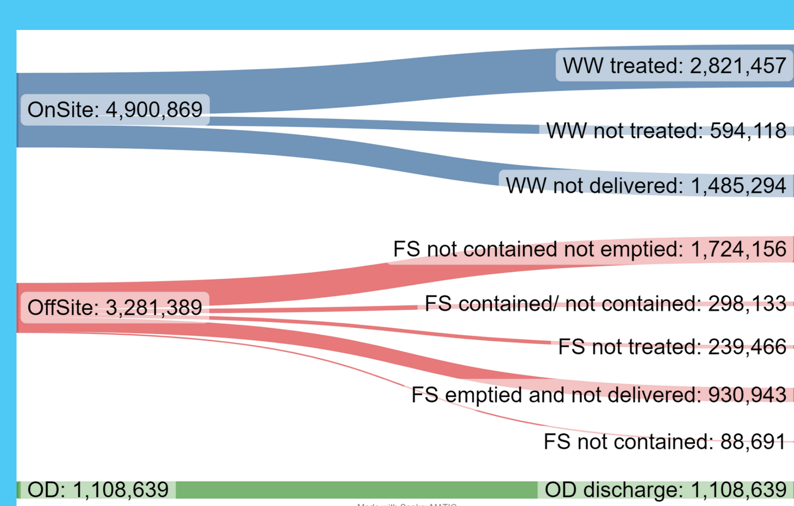




CO2







Fictionary Scenario

The following scenario was created as a fictional case in which the sanitation is at very low standards. Its use was necessary due to lack of data.

The total population was of 115000 and the percentages of Onsite, Offsite and open deffecation were 30%, 40% and 30% respectively. We can observe that compared to a more wealthy community methane production is low while the carbon dioxide and nitrous oxides are several times larger. This is due to the fact that poorer countries usually burn fossil fuels for transport and do not have advanced containment solutions.

Dar Es Salaam

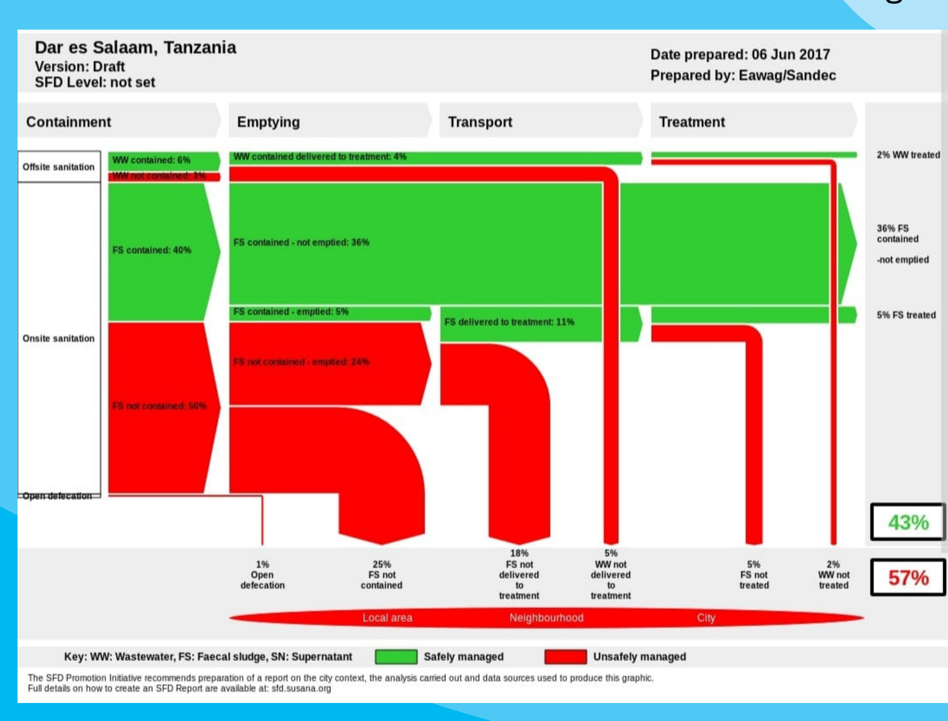
The following case distinguishes itself due to the large population of 4,365 mil.. However, its figures are comparable to the other two despite the size difference. This shows that there are fixed costs in terms of GHG emissions which cannot be spread across the number of people. The gases which increase more with population are the methane and nitruous oxide as they are directly related to the sludge/waterwaste produced.

Cape Code

This town represents a small highly developed town from USA. While it produces less CO2 the the dictionary case with a a similar amount of population, it is similar in terms of methane and nitruous oxide. The reduction in carbon dioxide is cause by more energy efficient treatment and transport processes. The other types of gases are not affected by this, but rather they are defendant on biological and chemical processes.

CONCLUSION

The following project has successfully made the transition possible from the SFD which is traditionally intended to raise awareness in underdeveloped areas to diagrams based on GHG emissions. The diagrams offer a clear visual quantification of the emissions from sanitation and water treatment and they uncover interesting facts. Besides displaying data, they allow comparisons between different cities based on geographical area, wealth, population etc. They display which areas need to be improved and incentivize the research community to gather more data and form a common analysis method similar to the inception of SFD in sanitation.



SFD diagram of Dar Es Salam[3]

1.Johnson, J., Zakaria, F., Nkurunziza, A., Way, C., Camargo-Valero, M. and Evans, B., 2022. Whole-system analysis reveals high greenhouse-gas emissions from citywide sanitation in Kampala, Uganda
2.Iopscience.iop.org. 2022. ShieldSquare Captcha. [online] Available at: <https://iopscience.iop.org/article/10.1088/1755-1315/724/1/012031/pdf>
3.Schroeder, E., 2022. Shit flow diagrams (SFD) - Sustainable Sanitation Alliance (SuSanA). [online] Susana.org. Available at: <https://www.susana.org/en/knowledge-hub/shit-flow-diagrams-sfds-excreta-flow-diagrams#> ..