Preliminary code for sizing an upflow anaerobic reactor (UASB) for domestic sewage

Santos, H. K. S.*, Santos, A. L. A.**, Lima, R. G. S.*** Lima, D. M. F****

***Civil Engineer, master's student at the Federal University of Sergipe. hellensaleseng@gmail.com.**

****Civil Engineer, Master's student at the Federal University of Sergipe. analarah.santos@gmail.com.**

*****Civil Engineer, Master's student at the Federal University of Sergipe. ronaldomuri424@gmail.com.**

******Civil Engineer, lecturer at the Federal University of Sergipe. danielmfl@academico.ufs.br.**

Highlights:

- **This work aimed to develop a code in Python 3 to optimize the sizing of UASBs and facilitate teaching;**
- **The code is preliminary because it follows specific boundary conditions;**
- **The dimensioned values of the UASB are returned: such as the volume, base area, length, width and height.**

Keywords: Python; programming; software.

INTRODUCTION

Demographic and industrial growth can have negative consequences for the environment, such as the pollution of natural resources. In response to these challenges, the last few decades have seen the development of various systems based on the application of anaerobic digestion to remove organic material from effluents, such as Upflow Anaerobic Sludge Blanket Reactors (UASB) (Silveira Filho, Mensah, Battiston, Barros, & Santos, 2018). In this scenario, the importance of optimizing processes through software arises, as it drives improvements in decision-making, increases operational efficiency and reduces rework (Aroucha Junior, Soares, Pires, & Leite Neto, 2024).

The aim of this work was to develop a programming code for sizing a UASB for domestic sewage.

METHODOLOGY

The Python 3 programming language was used to develop the code, so that the routine developed included inputs (temperature, Hydraulic Detention Time - HDT, sewage flow, reactor height, width/length ratio and average COD concentration in the UASB reactor) and outputs (reactor volume, width, length and area and Volumetric Organic Load - VOL).

The theoretical basis for the design of the UASB included NBR 12.209 (ABNT, 2011) and the main guidelines, criteria and design parameters presented by Chernicharo (2007) and Lettinga & Hulshoff Pol (1995). The proposed sizing code presented the following boundary conditions: substrate is domestic sewage; minimum sewage temperature of 16º C and maximum of 26º C; previously known flow rate; rectangular reactor base and VOL with a limit of 20 kg COD/m3 (DQO - Chemical Oxygen Demand).

RESULTS AND CONCLUSIONS

The script was developed (Figure 1) and used a looping approach in which the user is free to change and/or round off the values of the reactor's dimensions, such as width and length. Thus, as pointed out by Aroucha Junior et al. (2024), process automation is a revolutionary force in civil engineering and reshapes both the conception and realization of projects.

```python
Temperatura = float(input("P: Qual é a temperatura do esgoto?(°C, exceto valores menores que 16°C)"))
#TDH tempo de detenção hidráulica
while Temperatura < 16:
    Temperatura = float(input("P: Qual é a temperatura do esgoto?(°C, exceto valores menores que 16°C)"))
if Temperatura >= 16 and Temperatura < 19:
    TDH = float(input("P: Insira o intervalo de detenção hidráulica mínimo entre 10 e 14h:"))
elif Temperatura == 19:
    TDH = float(input("P: Insira o intervalo de detenção hidráulica mínimo desejado entre 10 e 14h:"))
elif Temperatura >= 20 and Temperatura <= 26:
    TDH = float(input("P: Insira o intervalo de detenção hidráulica mínimo desejado entre 6 e 9h:"))
elif Temperatura > 26:
    TDH = float(input("P: Insira o intervalo de detenção hidráulica mínimo desejado que seja maior que 6h:"))
#volume do reator
Q = float(input("P: Qual é a vazão de esgoto de projeto?(m³/h)"))
V = round(int(TDH * Q), 2) #V = volume do uasb
print ("R:", V, "é o volume atual do UASB (m³).")
#caso queira arredondar ou dividir o número de unidades do UASB:
div = int(input("P: Sinalize a quantidade para repartir o volume em unidades diferentes. Se não, digite 1:"))
if div == 1:
    Vnovo = int(input("P: Digite, caso deseje alterar o valor. Do contrário, digite o valor anterior (m³):"))
else:
    Vnovo = V/div
    print("R: O volume novo do UASB é de:", Vnovo,"m³", "com total de", div, "unidades separadas.")
    Vnovo = int(input("P: Digite, caso deseje alterar o valor. Do contrário, digite o valor anterior (m³):"))
    print("R: O volume do UASB é de:", Vnovo,"m³", "com total de", div, "unidades separadas.")
#altura do reator
hreator = float(input("Qual será a altura total do reator UASB? (metros)"))
#área do reator
A = round(Vnovo/hreator, 2)
print ("R:", A, "é a área atual do UASB (m²)." )
Anovo = float(input("P: Digite, caso deseje alterar a área. Do contrário, digite o valor anterior (m):"))
pr = float(input("P: Insira a proporção de largura/comprimento:"))
x = round((Anovo/pr)**(0.5), 2) #comprimento do UASB
y = round((pr*x), 2) #largura do UASB
print("R: A área do UASB é de:", Anovo,"m²", "com medidas de:", y, "por", x, "m (largura x comprimento).")
ynovo = float(input("P: Digite, caso deseje alterar a largura. Do contrário, digite o valor anterior (m):"))
xnovo = float(input("P: Digite, caso deseje alterar o comprimento. Do contrário, digite o valor anterior (m):"))
Anovo = round((xnovo*ynovo), 2)
print("R: A área nova do UASB é de:", Anovo,"m²", "com medidas de:", ynovo, "por", xnovo, "metros (largura x comprimento).")
#verificação da carga orgânica
s = float(input("P: Insira a Concentração média de DQO afluente ao reator UASB (kg DQO/m³):"))
Qnovo = Q*24
cov = round((Qnovo*s/Vnovo), 2)
print("P: Valor do cov:", cov, "kg DQO/m3.dia.")
print("Verifique se a carga orgânica volumétrica (cov) está de acordo: até 20 kg DQO/m3.dia. Atente-se a possíveis instabilidades")
c = int(input("P:Se estiver de acordo, digite '1', caso contrário escreva '0'."))
if c == 0:
    print("R: Corrija o valor e tente novamente.")
```

Figure 1 - Preliminary UASB sizing routine.

Source: Authors (2024).

When starting the program, the user must enter the sewage temperature, the HDT, and the sewage flow rate, after which the volume of the reactor is returned by the program, and the

designer must inform whether they want the UASB volume to be broken down into a number of units, after which the height of the reactor is entered.

The area of the reactor is then calculated, and the user must enter the value of the width/length ratio of the rectangular base of the UASB. With this information, the area will be calculated and the program will return the calculated values for the width and length of the reactor.

It should be noted that the dimension results obtained can be presented in decimal form, which can make it difficult to build the treatment unit. With this in mind, after returning the values mentioned above, a window opens for the designer to enter the dimensions adopted, based on the previously calculated values, without modifying the proportion entered. In this way, the logic used reduces project design time, in line with the benefits of the study by Ejidike, Mewomo, Olawumi and Esangbedo (2024), which pointed out that the adoption of automation in the construction process increases productivity, improves safety, saves project design time, waste management and reduces labor costs.

Finally, the program calculates the VOL and returns the calculated value, after which the user has the option of accepting the sizing if the load meets the estimated parameters for domestic sewage, or rejecting it if the value is above this limit.

It can be concluded that the program is effective in the volume and area sizing stages. The application of the script is extended to designers, with the aim of adding efficiency to project design. It also extends to the academic sphere, as in addition to contributing to the acquisition of knowledge for students, an innovative way of sizing reactors is developed, encouraging students to develop new codes and promote work in the field of optimization, using programming as the main tool.

For future studies, it is suggested that the code be expanded to cover situations with values outside the ranges, different flow rates and types of sewage, different base geometries and also the ordering of pipes for the distribution of sewage in the UASB.

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