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Efficiency of filters as rural basic treatment, manipulating an experimental unit located in water purification systems using plastic nozzle as a filter medium.

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Abstract
The title of the work is due to an in situ experimentation, where the design and efficiency of the filtration unit that contains a filter bed medium of plastic nozzle material is evaluated, with the aim of characterizing the water purification systems; determining the average flow of work and the physical, chemical and bacteriological parameters, prior to starting the filter; the installation of a scale experimentation unit, to study the efficiency of the filter with plastic nozzle material, with an ascending and descending flow mechanism, as a water purification process; and the determination of the filter efficiency with plastic nozzle material, with ascending and descending mechanism, through the application of mathematical theories, which guarantee a good design of the unit.
The evaluation consists of taking samples of the water before it enters the filter and after it leaves the filter, to later determine the content of: pH, odor, turbidity and dissolved oxide. Finally, we will proceed to the methodological establishment of the design of the filter unit with plastic bottle nozzle material as a recyclable material with an ascending and descending vertical flow mechanism.
Keywords*: Design, filter, flow, flocs, transport, water quality, linear correlation, type of flow.*

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I. Introduction

The present work constitutes the first stage of a humble effort, the result of three years of studying the dynamics of filters, and teaching the subject Sanitary Engineering, in the Department of Construction for the Civil Engineering career. An effort that is intended to expand and improve in the future with new studies, in order to form a basic work for the design of filter mechanisms, adapted to the conditions of Nicaragua, but which can also be used in other countries.

The motivation to make this document arises from the need to have basic methodological material for specialists and future professionals, which, adapted to the real conditions of our country, and adapted to the program that is taught in the Sanitary Engineering class in the Civil Engineering career, forms a base text, since its content implies the review of a wide bibliography that, in addition to being expensive, is scarce in our country.

II. Objective

In general, it will then be the evaluation of the efficiency of filters with plastic nozzle material, with an ascending and descending vertical flow mechanism as a water purification process in rural areas, through a scale experimentation unit for the design.

And specifically, it describes:
- Characterization of water purification systems for human consumption;
- Determination of the average flow;
- The installation of a scale experimentation unit to study the efficiency of the filter with plastic nozzle material;
- Determination of design criteria to size a filter with plastic nozzle material.

III. Methodological Design

Kind of Investigation

Based on the proposed objectives and the problem to be solved, this work is considered an exploratory, analytical and applied type of research; since the efficiency of the filters has to be studied, proposing the design criteria with mathematical methods in which graphs will be built for the analysis of the different variables that they contain in the dimensioning.

Execution Time

The research is developed in a period of three and a half months, distributed as follows: making the diagnosis in two weeks; determination of the flow in a week; unit installation, one week; determination of criteria for filter design four weeks; and drafting of the final document two weeks. For which it begins on March 1, 2010.

Data Collection Sources and Techniques

Primary Sources

- Study area, visit to the laboratory for photography.
- Expert engineers in the field, ENACAL, INAA, INETER to collect information.
- Capacity for the determination of the flow for the design of the filter.

Secondary Sources

- Library of the National University of Engineering (UNI), to review and collect information from books on the hydrodynamics of filters.
- Library of the National Autonomous University of Nicaragua (UNAN-Managua).
- Center for Research on Aquatic Resources (CIRA).
- Nicaraguan Company of Aqueducts and Sewers (ENACAL).
- Nicaraguan Institute of Aqueducts and Sewers, regulatory entity (INAA).
- Internet, visits to portals with basic information on the dynamics of filters, criteria and standards.

Data Collection Instruments

On-site observation: a structured observation guide will be carried out on the behavior of the filter, subjecting it to different liquid flows in which solid flow, hydraulic retention time, physical, chemical and bacteriological parameters, clogging, permeability, granulometry of the filter material, will be studied. Chemical and mechanical resistance of the filter material, particle shape, hydraulic load, operating speed, and efficiency.

Interviews: structured questionnaire guides will be carried out in order to obtain design criteria most used in the practical part of design and to recognize how each of the aforementioned parameters is determined.

Documentary analysis: a summary is used in which the main titles to be used in the revised bibliography were exposed, to achieve speed in locating the topics when they were used in the writing of the document. It also made it easier to identify factors that influence filter design.

Data Processing Techniques

The data obtained in the experimentation for the design of the filter will be processed by means of tabulations in which the parameters will be coded, assigning a numerical value to each one, in order to classify the information, enter the results and process it through the Microsoft Excel program.

The data from the interviews and the on-site observation will be processed using information summary and indexing techniques for easier location and handling.

Data Analysis Techniques

Content analysis: a content analysis will be carried out based on the data projected by the summary and indexing of the variables by means of a graph, to determine the most relevant factors in the design of the filters.}

Table 1: *Operationalization of the variables*

Type of Variable	Variables	Sub-variables	Indicator	Scale	Unit of value
Independent	liquid flow	Volume	m^3	$0.01m^3$-5 m^3	Suitable
		Hydraulic retention time	Horas	1h -19h	Suitable

		operating speed	cm/s	<2400 cm/s	Optimum
		Hydraulic load	m	0.5m-1m	Suitable
Dependent	physical quality of water	smell	___________ ___	----------------------	Suitable
		Turbidity	UNT	<5UTN	Optimum
		Colour	U Pt-Co	<U Pt-Co	Optimum
Dependent	Chemical quality of the water	pH	Min. 6 Max. 8.5	6 - 8.5	Optimum
Dependent	Biochemical water quality	Dissolved Oxygen (DO)	mg/l	4.0 mg/l<	Optimum
Independent	solid flow	Volume	m^3	$0.01m^3$-$5\ m^3$	Suitable
		Hydraulic retention time	Horas	1h -19h	Suitable
		operating speed	cm/s	<2400 cm/s	Optimum
Independent	Filter material granulometry	clogging	m^3	$0.01m^3$-$5\ m^3$	Optimum
		Permeability	cm/s	<2400 cm/s	Optimum
		Chemical and mechanical resistance of the material, shape of the particles	mm	0,005mm—2,0mm	Optimum
		Efficiency	%	50%<	Efficient

Source: self made. (2010)

Plastic Mouthpiece Material

Material that is used to remove the flocs, in which the water to be purified is filtered drop by drop, these are deposited adhering without any problem. Bacteria and other microorganisms stick to the plastic and remove the nutrients and organic matter dissolved in the water, this biodegradation of organic matter is done in the presence of oxygen for this reason the process is also known as anaerobic treatment. See figure 1.

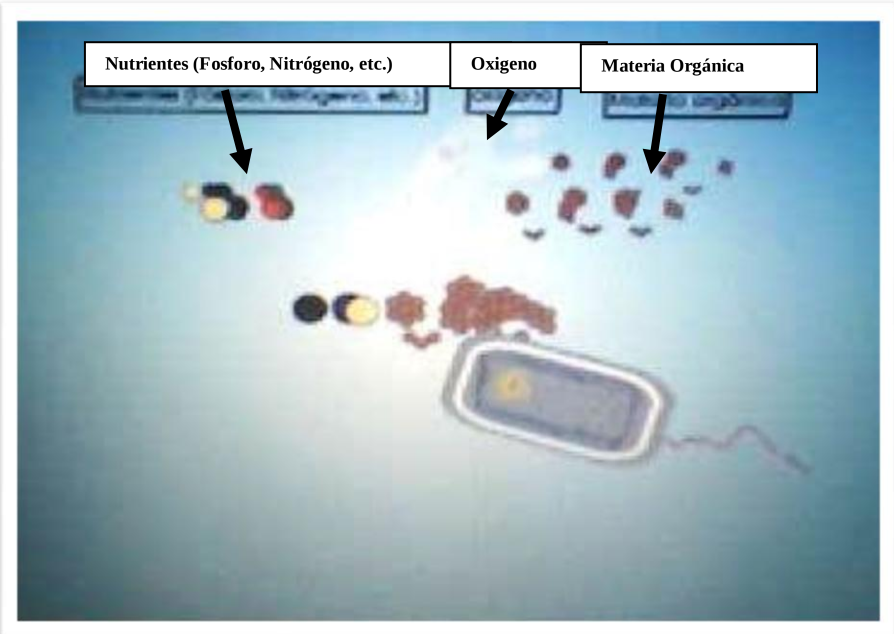

Figure 1: *Microorganisms in floc forms adhering to plastic*

Source: self made. (2010).

Filtration Hydraulics

At the velocities generally used for granular filters for water, the flow is normally laminar and obeys Darcy's law, v=Ks, where v is the frontal or approach velocity of the water on the sand bed; s=h/L is the head loss, h, in a bed depth L; and K is the Darcy coefficient of permeability. The identifiable components of the Darcy coefficient K are the density γ, and the viscosity μ, of the water, the porosity f, of the bed, and the size and shape of the constituent sand grains that determine the surface area A of the grains within it. of the bed in relation to its volume ∀.

Loss of Loads
The maximum filtration rate for a given water is a function of:
The quality of water that you want to obtain.
The speed with which the pressure drop develops in the filter.
Both parameters depend on the quality of the influent floc (whether it is hard or soft) and the size and type of filter media.
If the floc is hard and the medium is fine (E≤0.55 mm), almost all the head loss occurs in the first 5 cm for short rats (120 m3/m2/day) and is distributed a little more for tall rats (<240 m3/m2/day).

The greater or lesser distribution of the pressure drop in the filter bed is a function of the floc penetration. If the floc penetrates deeply, the distribution is much greater and the filtration run is also longer for the same filtration rate than when the penetration is only superficial. High rats have the advantage of inducing deeper penetration, but they can impair the quality of the effluent, especially when the floc is soft, since it could break inside the bed and come out in the filtered water.

Supernatant Charge
From the foregoing, it can be deduced that the smaller the layer of water Px that goes over the filter medium, the more easily negative pressures are obtained in the filter and the greater the probability that air blockages will occur. Traditionally, therefore, the filters are built with water layers of 1.40m to 1.80m. Some designers, however, leave depths of only 0.50m, which often causes problems. See figure 2.

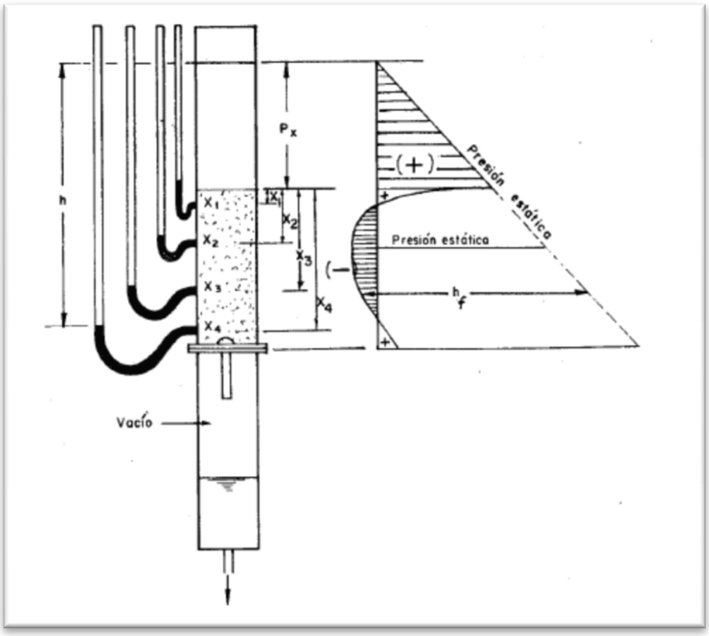

Figure 2: Diagram of Supernatant Load in a filter.
Source: self made. (2010)

Hydraulic properties of the filter material

Problems relating to liquid flow can generally be divided into two main groups, those dealing with laminar flow and those dealing with turbulent flow.

Badillo, J., Rodríguez, R. (2008), defines two types of flow: “Laminar flow is defined as the flow lines remain without joining each other and the particles move parallel throughout their length. Turbulent flow occurs when the above condition is not met.

It is known that at low velocities a flow occurs in a laminar form, while when those velocities increase, a limit is reached where it becomes turbulent; if at that point the speed is reduced, the flow will be laminar again, but the new transition generally occurs at a lower speed than the first. This indicates the existence of a range of velocities in which the flow can be laminar or turbulent, Reynolds proved that there is a certain velocity in each liquid below which, for a certain conduit diameter and at a given temperature, the flow is always laminate. This speed is defined as critical. Similarly, there is a higher velocity above which the flow is always turbulent; in the case of water, this second speed is approximately equal to 6.5 times the critical speed. Reynolds found that the critical speed of water can be expressed by Equation 1.

$$v_c = \frac{36}{1+0.0337*T+0.00022*T^2} * \frac{1}{D} \text{ ecuation 1}$$

Where:
vc = critical speed, (cm/s)
T = water temperature, °C
D = pipe diameter, (cm)

Darcy's Law and Permeability Coefficient

Badillo, J., Rodríguez, R. (2008), conceptualize that the flow of water through porous media is of great interest for the study as a filter medium, and is governed by a law discovered experimentally by Henry Darcy in 1856.

Darcy, H. (1856) investigated the characteristics of the flow of water through filters, formed precisely by earth materials, which is particularly fortunate for the application of the results to soils that function as a filter medium.

Working with specially designed devices, Darcy found that, for sufficiently small speeds, the cost is expressed by equation 2:

$$Q = \frac{dV}{dt} = kAi \; (cm^3/_s) \text{ ecuation 2}$$

Where:
A= total cross-sectional area, (cm2).
i= hydraulic gradient of the flow, measured with the expression:

$$i \frac{h_1 - h_2}{L} \quad \text{ecuation 3}$$

Where:
h1-h2 = energy losses (cm)
L = displacement in (cm)
In the following figure 3, the hydraulic gradient is analyzed.

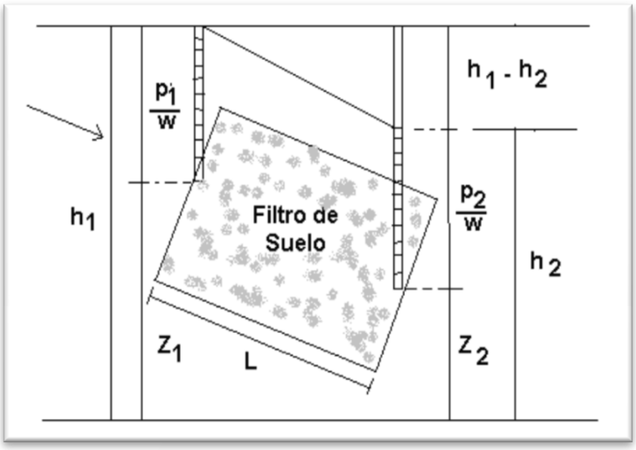

Figure 3: Darcy's experimental device.
Source: Own elaboration, based on Badillo, J., Rodriguez, R. (2008)

The spending continuity equation states that:

$$Q = Av \; (cm^3/_s) \quad \text{ecuation 4}$$

Where A is the area of the duct and the velocity of the flow. Bringing this expression to equation 5, it follows that:

$$v = ki \text{ ecuation 5}$$

Download Speed, Filter Speed and Real Speed

Consider a soil filter as in Figure 4. The soil is represented by dividing it into its two phases of solids and voids. Note that in this the area available for the passage of water is Av instead of A, as assumed in Darcy's law. If the flow is established, however, the same rate should be had in the free pipe as in the ground; therefore, taking into account the continuity condition, the following can be analyzed:

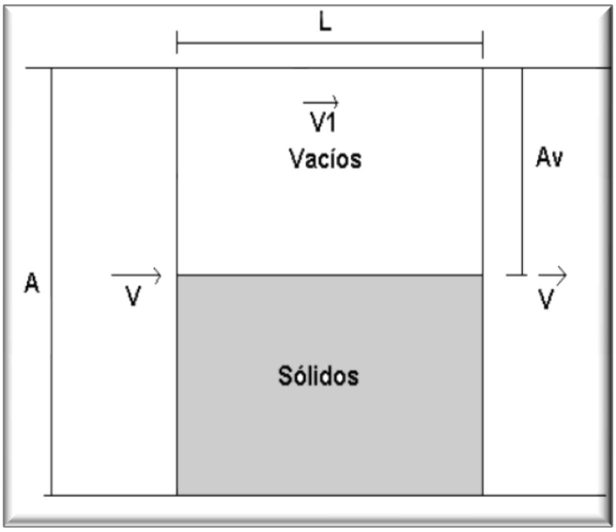

Figure 4: Schematic representation of the speed in a filter medium.
Source: Own elaboration, based on Badillo, J., Rodriguez, R. (2008)

Where from:

$$A_v v_1 = Av \quad \text{ecuation 6}$$

Clearing v1 we have

$$v_1 = \frac{A}{A_v} v \quad \text{ecuation 7}$$

Considering the filter a unit thickness normal to the paper, we have:

$$\frac{A}{A_v} = \frac{1}{n} = \frac{1+e}{e} \quad \text{ecuation 8}$$

Substituting equation 7 in equation 8 we have:

$$v_1 = \frac{1+e}{e} v \quad \text{ecuation 9}$$

The speed v, which follows directly from Darcy's law, is called the download speed, or simply speed. The speed v1 that takes into account the existence of an impermeable solid phase is called the filtration speed, and it is the average speed of advance of the water in the direction of flow.

However, in obtaining the filtration speed, it was assumed that the water had a straight path as it passed through the filter, which is why it does not represent the speed with which the water is moving. The water does not travel the length L when passing through the ground, but rather a sinuous or irregular line of length Lm. So if v2 is the real average speed that is a function of length, we have:

$$v_2 = v_1 \frac{1+e}{e} \frac{Lm}{L} v \quad \text{ecuation 10}$$

A more realistic mean velocity could only be found if the pore area variations in each channel are known.

IV. Results

Result of the Water Characterization

A water sample was analyzed to characterize its quality, in which the physical-chemical and biological analysis was taken into account, together with the parameters of interest, resulting in a type 1-B water, in the following table the results are described.

Table 2: *Results of the physical-chemical parameters studied*

Agua para consumo humano Tipo 1B												
Temperatura	25°C											
Parámetro	**Límites o Rango**		**Resultados**									
	Mínimo	Máximo	**MA-1**	**MA-2**	**MA-3**	**MA-4**	**MA-5**	**MA-6**	**MA-7**	**MA-8**	**MA-9**	**MA-10**
pH	6.0	8.5	9.0	7.0	9.5	7.8	9.1	8.4	7.4	8.2	8.0	9.5
Conductividad eléctrica	-	-	90 mh/cm	80 mh/cm	92 mh/cm	97 mh/cm	94 mh/cm	92 mh/cm	88 mh/cm	97 mh/cm	98 mh/cm	99 mh/cm
Sólido Disuelto		<1500 mg/l	670	650	630	800	1000	900	1100	1000	980	780
Turbidez		<250 UNT	300	320	210	280	270	275	278	280	287	290
Color		<150 U Pt-Co	160	165	155	170	176	190	158	180	160	174
Dureza de los Floculos		<400 mg/l	380	401	410	390	415	407	395	409	410	405
Hierro total		<3 mg/l	3.5	4	3.9	3.8	4.1	3.6	2.9	3.8	3.1	3.42
	mh= microhoms											
	MA= muestra de agua											

Table 3: *Results of the biological parameters studied*

Agua para consumo humano Tipo 1B												
Temperatura	25°C											
Parámetro	**Límites o Rango**		**Resultados**									
	Mínimo	Máximo	**MA-1**	**MA-2**	**MA-3**	**MA-4**	**MA-5**	**MA-6**	**MA-7**	**MA-8**	**MA-9**	**MA-10**
Oxigeno Disuelto		4.0 mg/l<	3.9	4.1	4.0	4.5	4.4	5.0	4.2	3.9	4.9	4.3
DBO		<5.0 mg/l	5.0	5.1	5.9	6.0	5.5	6.4	5.9	5.1	5.8	6.0
DQO	-	-	-	-	-	-	-	-	-	-	-	-
	MA= muestra de agua											

The linear correlation between dissolved solid parameters and turbidity was verified, using least squares, since this postulate brings an approximation of the dependent variable, in this case it is turbidity to the independent variable, in the case of dissolved solids.

On the other hand, there is a trend relationship between both variables, that is, for a certain amount of dissolved solids, a certain amount of turbidity corresponds, thus projecting a binding relationship between the manipulated variables, since turbidity depends a lot on the amount of dissolved solids.

Both present an almost linear behavior when these are corrected. For this reason, least squares was used. It is notorious that with the application of the approximation the behavior of the data of the dependent variable (turbidity) is lost. The following figure shows the correlation.

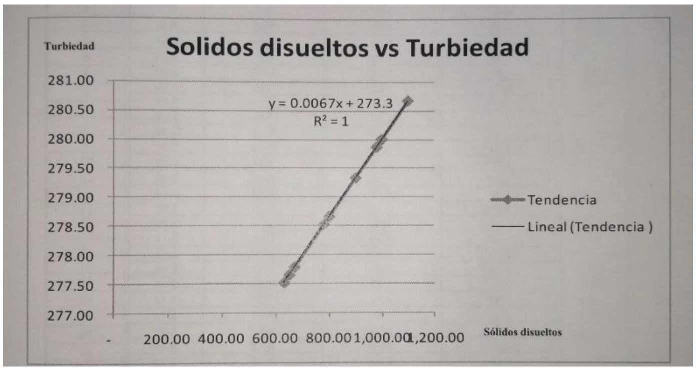

Figure 5: Correlation between dissolved solids and turbidity.

Source: (Tirado Picado, 2010)

Describing the following analysis, that the closer the parameter is to the value 1, the greater precision or closeness to the curve of the data considered in the estimation will be. Therefore, it was concluded that total solids and turbidity are highly correlated.

Population Estimation Result and Design Flow

The population was determined for subsequent years, having 2010 as the base year, for which water will be consumed, the projection that was made for a certain rural area, this does not mean that the methodology can be carried out for an urban area.

The systematic application to determine the real flow based on the population size was carried out for the analysis of a correlation with the filtration units to be used. For this, the analytical method was developed, and any population was projected for 20 years at a population growth rate of 2.5%, 2.7%, and 4%. See the following table.

Table 4: Summary of projection of flow and average.

Proyección del 2.7%	Proyección del 2.5%	Proyección del 4.0%	Promedio
CMD=1.5CDPT	CMD=1.5CDPT	CMD=1.5CDPT	l/s
l/s	l/s	l/s	
1.81	1.81	1.81	1.81
1.86	1.86	1.89	1.87
1.91	1.90	1.96	1.93
1.96	1.95	2.04	1.98
2.02	2.00	2.12	2.05
2.07	2.05	2.21	2.11
2.13	2.10	2.29	2.17
2.18	2.15	2.39	2.24
2.24	2.21	2.48	2.31
2.30	2.26	2.58	2.38
2.37	2.32	2.68	2.46
2.43	2.38	2.79	2.53
2.50	2.44	2.90	2.61
2.56	2.50	3.02	2.69
2.63	2.56	3.14	2.78
2.70	2.63	3.26	2.86
2.78	2.69	3.39	2.95
2.85	2.76	3.53	3.05
2.93	2.83	3.67	3.14
3.01	2.90	3.82	3.24
3.09	2.97	3.97	3.34
3.17	3.04	4.13	3.45
3.26	3.12	4.30	3.56
3.35	3.20	4.47	3.67
3.44	3.28	4.65	3.79
3.53	3.36	4.83	3.91
3.62	3.44	5.03	4.03
3.72	3.53	5.23	4.16
3.82	3.62	5.44	4.29
3.92	3.71	5.65	4.43
4.03	3.80	5.88	4.57

Source: (Tirado Picado, 2010)

Obviously, the hydraulic bench accessory, FME00, provides the necessary facilities to support a comprehensive range of hydraulic models which have been designed to demonstrate a particular aspect of fluid theory.

The laws of conservation of mass, energy and momentum can be simplified in order to quantitatively describe the behavior of the fluid. Fluid mechanics has been developed as an analytical discipline of the applications of the classical laws of statistics, dynamics and thermodynamics, to situations in which the fluid can be treated as a continuous medium, in the following table is the summary of the flow with hydraulic bench.

Table 5: Summary of capacity with the BH

Cuadal ideal calculado con el Banco Hidráulico					
Iten	Volumen Inicial	Volumen final	Volumen Registrado	Tiempo registrado	Caudal
	Litros	Litros	Litros	Segundos	l/s
1	0	10	10	45.20	0.22
2	0	10	10	48.60	0.21
3	0	10	10	44.50	0.22
4	0	10	10	47.39	0.21
5	0	10	10	44.21	0.23
6	0	10	10	45.40	0.22
7	0	10	10	46.60	0.21
8	0	10	10	45.30	0.22
9	0	10	10	45.29	0.22
10	0	10	10	47.30	0.21
11	5	15	10	44.21	0.23
12	5	15	10	44.10	0.23
13	5	15	10	45.90	0.22
14	5	15	10	46.50	0.22
15	5	15	10	45.64	0.22
16	5	15	10	43.20	0.23
17	5	15	10	45.23	0.22
18	5	15	10	47.32	0.21
19	5	15	10	46.24	0.22
20	5	15	10	44.32	0.23
21	5	15	10	44.24	0.23
22	5	15	10	45.32	0.22
23	5	15	10	46.57	0.21
24	5	15	10	47.32	0.21
25	5	15	10	46.71	0.21
26	5	15	10	44.30	0.23
27	5	15	10	47.23	0.21
28	5	15	10	46.56	0.21
29	5	15	10	46.31	0.22
30	5	15	10	45.71	0.22
31	5	15	10	44.56	0.22

Source: (Tirado Picado, 2010)

Then, the average of the calculated flows is related to the flow obtained with the hydraulic bench and an equivalent ratio or coefficient of ideal terms to real terms was obtained. See Figure.

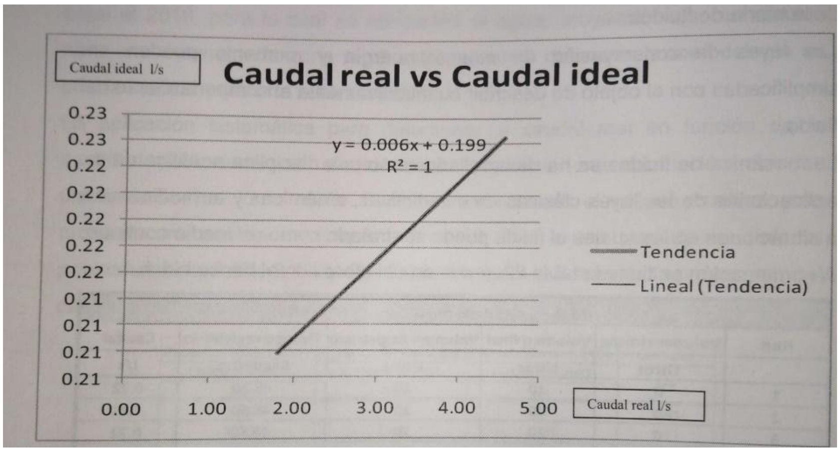

Figure 6: Correlation of the actual flow rate with the ideal flow rate
Source: (Tirado Picado, 2010)

Given that the use of least squares was made with the purpose of approximating the dependent variable, in this case it is the ideal flow to the independent variable, in the real flow case; and establish a trend relationship between the two variables, in other words, that, for a real flow rate, an ideal flow rate corresponds, then obtain a binding relationship between the two variables, since the ideal flow rate depends a lot on the real flow rate.

And as a result, both variables present an almost linear behavior when these are corrected. It is notorious that with the application of the approximation the behavior of the data of the dependent variable (ideal flow) is lost.

Thus, for a flow rate of 3 l/s, there is an ideal flow rate of 0.22 l/s, which is the theoretical liquid flow rate used for the design of the filter.

Solid Flow Determination Result

With respect to colloidal particles, these have certain characteristics that allow them to adjust to each other to obtain sufficient weight and settle due to the effect of gravity in a short time.

That is why the objective of the coagulation process is the stabilization of the particles by neutralizing the forces that keep the particles separated in such a way that they form larger particles called flocs and that will later be removed by sedimentation, filtration or a combination of several processes. For the process I am interested in the study of filtration.

To be sure, there is no definite limit to colloidal particles, but they are generally considered to be between 1 and 1000 millimeters (mμ). The limits listed in the following figure are approximate since the size and nature of the material determine whether the particle is colloidal.

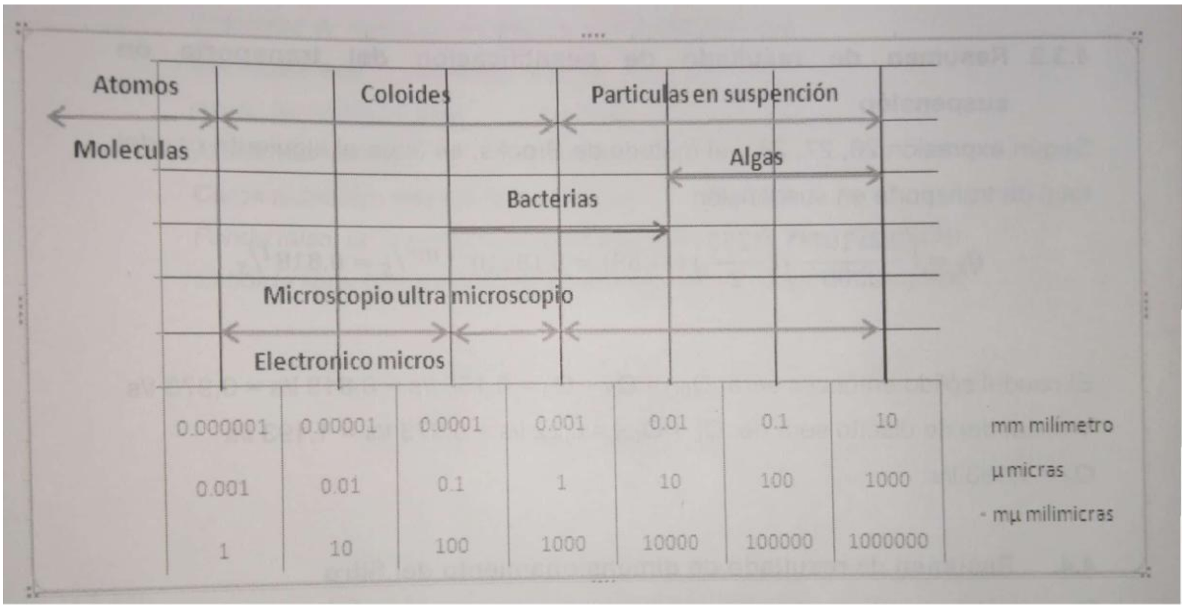

Figure 7: Colloidal particle size ranges
Source: (Tirado Picado, 2010)

In other words, for the design, the interval between 0.001 mm and 10 mm was considered as the effective size of the particle, and an average value of 5.0005 mm was used. Given that the thickness will be B = 2x5.0005 mm = 10.01 mm.

Result of the Calculation of the Total Bottom Transport
Regarding the calculation of the total bottom transport, certain field data were considered, which are described below**:**
Temperature T°C = 25
Specific weight of water at indicated temperature, γ = 0.9974 gr/cm3
Specific weight of the floc particle, γ = 1,250 gr/cm3
Floc diameter in mm, as above, 0.005 mm
n' roughness due to the floc particle
n roughness due to the filter material, in the case of the plastic nozzle 0.009
Kinematic viscosity at indicated temperature, υ25°C = 0.89x10-6 m2/s

By the Meyer-Peter and Müller method, the following total bottom flow is obtained:

$$Q_B = (5{,}54) * (0{,}028) = 0{,}155\ l/s$$

Suspension transport quantification result
Using the Brooks method, we have the following total flow rate of transport in suspension

$$Q_S = \left(\frac{2{,}2x10^{-4}}{2000}\right)\left(\frac{1250}{2}\right)(11{,}88) = 8{,}8x10^{-4}\ {m^3}/{s} = 0{,}818\ l/s$$

The solid flow will then be: QSO = QB+QS = 0.155 + 0.818 = 0.973 l/s
And the design flow will be: QL +QSO = 0.22 + 0.973 = 1.193 l/s

Filter Sizing Result

In relation to the analysis of the dimensioning of the filter, it is done from the continuity equation to determine the critical speed, filtration speed and the real speed, as well as the diameter of the filter, filter area, length of the filter bed, load on swimmers, the following results were obtained:

Filter diameter: $\varphi = 2.41$ m
Filter area: $A = 4.56$ m2
Critical speed = $Vc = 0.026152$ cm/s
Reynolds: $Re = 703.41$
Discharge or filtration velocity: $V1 = 0.052304$ cm/s
Actual speed: $V2 = 0.02612$cm/s
Filter bed height: $L=2.34$ m
Total filter height: $H = 4.68$ m
Hydraulic load on the filter bed: $h = 2.34$m

And the final hydraulic conditions are:
Design flow: $Qd = 1.193$ l/s = 103.08 m3/day
Filter diameter: $\varphi = 2.41$m
Filter area: $A = 4.56$ m2
Critical speed = $Vc = 0.026152$ cm/s
Reynolds: $Re = 703.41$
Discharge or filtration velocity: $V1 = 0.052304$ cm/s
Actual speed: $V2 = 0.02612$cm/s
Filter bed height: $L=2.34$ m
Total filter height: $H = 4.68$ m
Hydraulic load on the filter bed: $h = 2.34$m
False bottom, included in a range of: $0.15m \leq FS \leq 0.30m$
The free edge, included in an interval of: $0.15m \leq BL \leq 0.30m$

V. Conclusion

With respect to filter design, the following water quality parameters should be considered: first, the physical parameters: pH, electrical conductivity, dissolved solids, turbidity, color, floc hardness, total iron; second, the chemical parameters: dissolved oxide, BOD, COD; since, this established the type of water for the analysis, as a consequence, type 1B was given as a result.

Regarding the projection of the population, any population was taught to determine the design liquid flow, and the work area was established to project for 20 years, and together with the endowment that adjusts to the requirements according to the demand, it is calculated per year.

With respect to the scientificity that involves the effectiveness of the operation of the purification equipment, I imply theorems, equations and postulates, since these in turn are developed from their definitions, then a procedure for the design of the filter is proposed.

And finally, an analysis was carried out from the continuity equation to determine the hydraulic conditions, this expression was proposed to facilitate the design results even better. The dimensions to be calculated are: the critical speed, filtration speed, real speed, as well as the diameter of the section, filter area, length of the filter bed and the supernatant load.

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Bibliographic References

[1]. Badillo , J., & Rodriguez, R. (2008). Mecánica de Suelos: Tomo 1, Fundamentos de la mecánica de suelos. México, D.F.: LIMUSA.
[2]. Baldizon, M. E. (S.f.). Apuntes de Ingenieria Sanitaria II. Potabilización del Agua. Managua, Nicaragua.
[3]. Baldizon, M. E. (s.f.). Apuntes de Ingenieria Sanitaria: Potabilización del agua. Managua, Nicaragua.
[4]. Barbey Sánchez, R. (1988). Mecanica de suelos. Habana: PUEBLO Y EDUCACIÓN.
[5]. Comisión Federal de Electricidad. (S.f.). Manual de Diseño de Obras Civiles, Hidrotecnia. México D.F., México.
[6]. ENACAL. (2010). Resultados de Calidad de Agua. Managua, Nicaragua.
[7]. Fair, G. (1979). Purificación de aguas y tratamiento y remosion de aguas residuales: 2 Ingenieria Sanitaria y de agua residuales. México D.F.: LIMUSA, S.A.
[8]. Henry Philibert, G. (S.f.). Facultad de Agronomía, Departamento de Suelos y Recursos Naturales. Chillan, Chile.
[9]. INAA. (1998). Normas para Sistemas de Tratamiento de Aguas Servidas Dómesticas (NTON 05-008-98). Managua, Nicaragua: INAA.
[10]. INAA. (1999). Normas técnicas para el diseño de abastecimiento y potabilización del agua (NTON 09003-99). Managua, Nicaragua: INAA.
[11]. McGHEE , T. (1999). Abastecimiento de agua y alcantarillado: Ingenieria Ambiental. México: McGraw-Hill.
[12]. Mercado Sánchez, C., Altamirano, M. A., & Rosales, J. S. (2008). Registro de medición de caudal y párametro físico en muestra compuesta. Managua, Nicaragua: INFORME CIRA-UNAN.
[13]. Moreno Ayestas, S. (1994). Apuntes de Hidrología de Superficie. Managua: Printart Editores.
[14]. Potter, M. C., Wiggert, D. C., & Hondzon, M. (1998). Mecánica de Fuildos. México D.F.: PRENTICE HALL.
[15]. Stewrt, J. (1994). Cálculo. México D.F.: Grupo Editorial Iberoamericana, S.A. de C.V.
[16]. Streeter, V. L. (2005). Mecánida de Fluido. México: McGraw-Hill.
[17]. Tirado Picado, V. R. (2010). Efficiency of filters as rural basic treatment, manipulating an experimental unit located in water purification systems using plastic nozzle as a filter medium. Managua: Honolulu, Hawai.
[18]. Vargas, L. (s.f.). Capitulo 3: Procesos unitarios y plantas de tratamientos. Lima, Perú: CEPIS.