Evaluation of methodology of filtration to protect fountains in places with risk of microbiologic contamination of water

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Abstract

This research was developed during april-2006 to january-2007, in the *Universidade Estadual do Centro Oeste*, CEDETEG Campus, in Guarapuava City, Parana State, Brazil. The main objective was to evaluate the efficiency of different filter compositions, to retain contaminate agents in water. Three models of filter were tested in order to check their efficiency to remove pathogenic organisms present in water contaminated by *Endolimax nana* and *Giardia lamblia* cysts, *Ascaris lumbricoides* eggs and *Ancylostoma duodenale* larvae. It is possible to say that, among the different filter compositions studied, the one that presented less indication of passage of contaminate agents during the process of filtration was the one that used layers, with the following components a) crushed stone, b) clayey soil, c) sand river d) industrial sand, and e) sand + pure clay in a combination of 50% (in substitution of use of TNT), represents an efficient alternative to retreat parasites of Endolimax nana cysts, cysts of Giardia lamblia, eggs of Ascaris lumbricoides and Ancylostoma duodenale when they are present as contaminate agents of water. The contaminate agents Endolimax nana cysts and eggs of Ascaris lumbricoides, were the most difficult agents to filtrate.

Key words: water decontamination, filters composition, consume of untreated water.

Introduction

The water destined to human use or to use in different activities should serve different quality requisites, which varies according to different realities. Naturally, the water may contain impure components, from physical, chemical and biological order and the amount of these, must be limited to a non-damaging level to human beings, when it is for direct consume, as is establish by public health organs, like patterns of drinking. (MOTTA, 1993).

According to Watson (1998), about a fifth of the world population doesn't have access to good water, and a third has no access to sanitation. Sodis (2003) points that, in the Latin America around 60 million of people don't have access to treated water, and most of the water distributed in rural areas is not chlorinated, exposing users to significant health risks.

The World Health Organization (OMS) estimates that 80% of diseases in developing countries are a result of water contamination (WORLD HEALTH ORGANIZATION, 1984). About 5 million of people die a year, due diseases related to consumption of non-potable water and lack of access to sanitation and good conditions of hygiene. (WATSON, 1998).

Approximately 25% of hospital beds in the world are filled with victims of diseases transmitted because of contaminate water. In Brazil, according to OMS, about 70% of hospitals beds have people with diseases by water contamination and, approximately twenty-nine people die daily, by lack of sanitation. (WORLD CONSERVATION UNION, 1991).

The data from the Program of the United Union to development reports that, Brazil has receded in terms of reducing by half the proportion of rural population with no access to sanitation. Almost two third of Brazilians that live out of urban areas still doesn't have the basic service. According to the authors, in terms of access of drinking water, the rural population also faces difficulties. Slightly more than half of people living outside the city limits have an efficient supply service. The IBGE (2003) describes that, according to the Associação Nacional dos Serviços Municipais – ASSEMAE, to each R$ 1,00 invested in sanitation, the public service would save R$ 4,00 in treatable medication; without a question, an important gain in economic and social terms.

Health professionals of Brazil make us aware that the biggest challenges of health system are specially, the hepatitis, malaria, yellow fever, cholera, schistosomiasis, the dengue, leishmaniasis and the hantavirose. With this list, it is possible to see, the importance of diseases caused by water or that have an important factor with environment. It's impossible to fight against these diseases leaving behind the rural

populations, in which an adequately capitation and use of water are more neglected than in big cities. (HOCHMAN, 1998).

The rural reality is generally characterized as a population with less access to sanitation measures and by the presence of farming activities that are highly imposing, and that might interfere in the water quality from fountains, many of these, supplying cities. The diagnostics of water use and the knowledge of these people in these areas, present risks to health of these populations and contamination and pollution of water sources that start or pass in these places.

According with Ferreira et al (2000) the microorganisms *Endolimax nana, Giardia lamblia, Ascaris lumbricoides e Ancylostoma duodenale* should be put as the main part of biological agents that can be present in water of contaminated sources, especially in rural areas. The minor specie of ameba found in humans is *Endolimax nana* and its cycle is typically oval, measuring eight micrometer (SOGAYAR *et al.*, 2000).

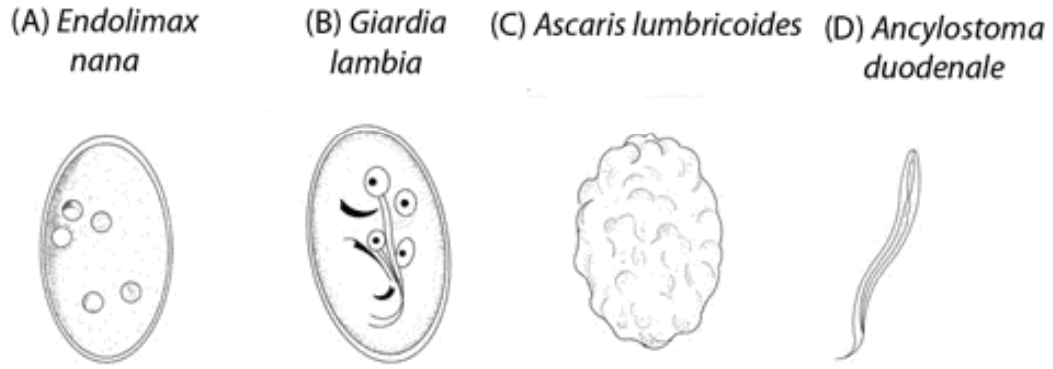
To this author the giardiasis is easily found in developing countries, like Brazil, because it is related with poor conditions of sanitation. The contamination happens through ingestion of cysts (ovoid, measuring about 12 micrometers long by 08 wide) with contaminate food or water. Among the most prevalent intestinal helminthes in humans is Ascaris lumbricoides. It is estimated that about 22% of world population is infected and 10% of the total of the parasitized individuals are found in Latin America (CROMPTON, 1998). The high prevalence of ascariases is considerate an indicator of impropriated sanitation, commonly observed in rural communities. Children are most affected and have the most significant clinical consequences of parasitic infection.

The fertile eggs are round and measure around 60 micrometers long and 45 wide. (STEPHENSON e HOLLAND, 1990; THEIN-HLAING et al.,1984).

Ancylostoma duodenale is one of the biggest problems of public health, since that is estimated that 1125 million, the number of parasitized individuals in the world, with over 65 thousand deaths a year. Contamination occurs through skin penetration by filarióides larvae or through the oral mucosa, by ingestion of infective filarióides larvae ingested with contaminated water. The average size of larvae varies from 08 to 11 mm long by 360 micrometers wide (Ferreira et al, 2000).

After a field search, Rocha (2006) observed that from 45 land owners interviewed, 41 of them have never done a laboratorial analyze of water. When they were asked about the important characteristics of home water, 30 of them said only the physical aspects (such as clear water, flavor and smell), 12 said that water should be filter, boiled or treated, and only 2 put the relevance of how important is the place where the water comes to be free of

Figure 1. Microorganisms used for contaminate water.



faeces. The author stands that only 24 land owners considered that characteristics of water to animal use should be similar to those of human use. However, the occurrence of diseases was only quoted by 11 interviewers.

It is known that, in most of the supplying systems from rural areas from developing countries, there is a general fecal contamination, and it is recommended to set a long-term goal to National organism of health surveillance, to gradually improve the supplying system.

Most of the rural diseases can be reduced, but is necessary to provide drinking water to population. The absence in many of founts, from all the protection factors that are recommended as important for the preservation of water quality, proves how important is to guide the people who use these waters, aiming to maintain its quality.(AMARAL et al., 2003).

To avoid diseases through water contamination, in places where there isn't treated water, is necessary to found an alternative treatment system, possible to reduce costs of implementation and operation, offering satisfactory conditions of sanitation. The choice of type of treatment will depend on economic, social, geographical factors and of physical-chemical and microbiologic quality of water to be treated. (FLEURY et al., 2005).

The protective structures of fountains are designed to avoid contamination, especially of drinking water, already in its origin, (CALHEIROS et al, 2004). Results of research carried out by Di Bernardo (1993) point to a slow filtration as a system treatment economic and efficient, and therefore quite appropriate to rural conditions. This work was carried out to evaluate the efficiency of different compositions of filters on the retention of agents that contaminate the water, to propose to establish a model of filter for use in natural sources of water, used, especially in rural areas.

Material and methods

This study was conducted during April 2006 to January 2007 at the Agricultural hydraulics laboratories with the Department of Agronomy and Parasitology at the Department of Biology at the Universidade Estadual do Centro-Oeste, Campus CEDETEG in Guarapuava-PR.

Three different types of filters were tested to verify their efficiency to remove pathogens from contaminated water with the main purpose of proposing alternatives that may be considered efficient in terms of filtering water, especially in rural conditions. The contaminated organisms present in water were Endolimax nana cysts of Giardia lamblia and Ascaris lumbricoides eggs and larvae of Ancylostoma duodenale. The contaminant material, previously selected, was taken from the Municipal Office of Health of Guarapuava with a laboratory for clinical analysis. The contaminated samples used in the experiment were diluted into estimated, pre- determined concentration of contaminants agents for each type of filter, which is, particularly, 2700 nana cysts of Endolimax, 2700 cysts of Giardia lamblia, Ascaris lumbricoides eggs from 2700 and 2700 larvae of Ancylostoma duodenale.

We analyzed three types of filters set up on tanks of cement / asbestos with volume capacity of 250 liters. The filters were composed in different ways, as follows:

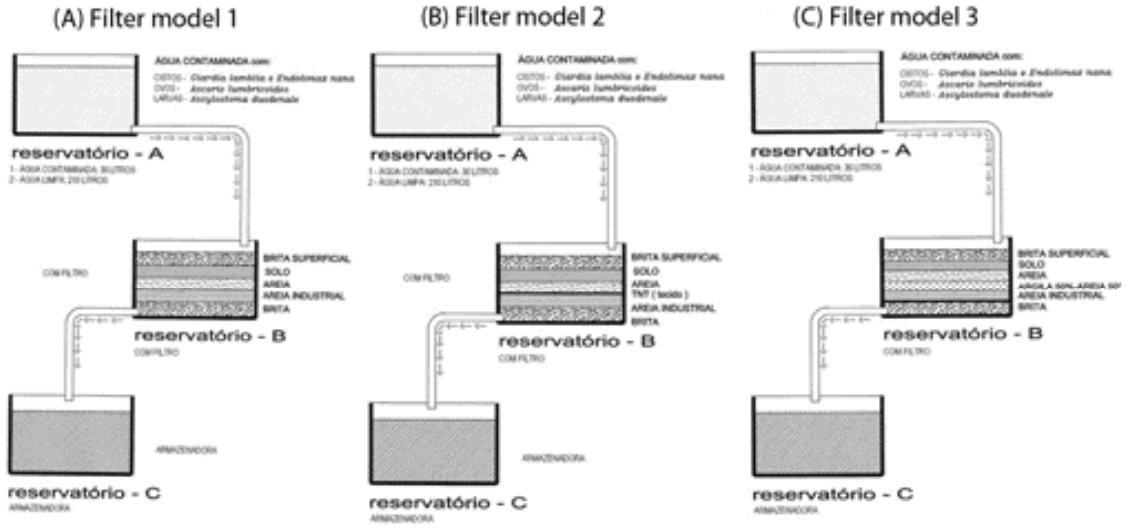
Model 1: filter composed of five layers of 10 cm disposed one on top of another, with the following materials, from top to bottom, respectively: number 1 crushed stone, soil classified as pure Latosol Bruno Distroférico typical, very clayey texture as established

Chart 1. The result of a chemical analyze of soil used in the layer called as clayey-sandy soil, from the different models of filters.

P	C	pH				dm^{-3}					%
Mg dm^{-3}	g dm^{-3}	$CaCl_2$ 0,01M	Al^{3+}	$H^+ + Al^{3+}$	Ca^{2+}	Mg^{2+}	K^+	Sb	CTC	V	M
0,65	22,5	6,4	0,1	4,28	7,0	5,7	0,18	12,80	18,11	74,98	0,80

P e K: extrator Mehlich^{-1}

Figure 2. Schematic drawing from filters models used in the experiment of water filtration with contaminate agents.



by methodology of EMBRAPA (2006), sand grain size median between coarse and fine, industrial sand (finely ground with a rock classified as sand) and crushed stone number 3, (Figure 1 - a).

Model 2: filter composed of six layers of 10 cm disposed one on top of another, with the following materials from top to bottom, respectively: number 1 crushed stone, soil classified as pure Latosol Bruno Distroférico typical, very clayey texture as established by methodology of EMBRAPA (2006), sand grain size median between coarse and fine, TNT (not tissue fabric), industrial sand and crushed stone number 3, (Figure 1 - b).

Model 3: filter composed of six layers of 10 cm disposed one on top of another, with the following materials, from top to bottom, respectively: number 1 crushed stone, soil classified as pure Latosol Bruno Distroférico typical, very clayey texture as established by methodology of EMBRAPA (2006), sand grain size median between coarse and fine, with 50% layer of sand and clay of 50% pure powder, industrial sand and crushed stone number 3, (Figure 1 - c).

The result from chemical analyze of soil used to compose the layer called as clayey-sandy soil is presented in chart 1:

To the process of filtration was used a group of 3 tanks (A, B and C) set in serie, where the water that flows from A to B and from B to C was kept with gravity. The tank A was put in a base of 4,50 m above the soil level, being used as a recipient to save the water used in the process of filtration. In tank B with base 0,50 m below the level from A, were set the different models of filters and tank C, installed on soil level, is where the water samples were collected after they went through the process of filtration .

The process of filtration was performed in two distinctive phases. In the first one, the tank A was supplied with 30 liters of contaminate water, that following the gravity process, was filter in tank B and collected in tank C. In the second phase, performed immediately after the first, the tank A was supplied with 210 litters of non-contaminate water, which followed the same process between tanks A until C, passing through the filter. The goal intended with the second phase was to check if the passage of water through the filter would result in contaminate agents kept in, during performance of phase 1.

To process of filtration, 90 liters of water were contaminated, and used in each model of filter, making possible to perform three repetitions of process of filtration, that was done separately to each contaminate agent, with the idea to facilitate the process of filtration.

For analysis of the filtered material, in each reproduction were collected samples scaled with a liter of volume of water that reached the tank C after filtration. In the first stage of filtration the samples were taken after the passage of the volume of 10, 20, 30 liters and a sample composed by the total volume. In the second stage of filtration, samples were collected after the passage of 70, 140, 210 liters and a sample composed by the total volume.

At the end of this process of repetition of evaluation from different models of filter, a sample, with approximately one kilogram, was collected in each of the layers of the material component of filters to evaluate possible differences in the efficiency of these layers in the process of filtering water. Completed the process of evaluating, the filter was removed and the material was discarded into proper place. Tanks A, B and C were decontaminated and models of filters and their repetitions were again set up for new tests in the tank B. These samples were stored in hermetically containers at room temperature and being preserved in formalin 10%. These were analyzed through tests of spontaneous sedimentation of Lutz (Lutz & Hoffman) and fluctuation (Willis), with reading of six slides per sample. The statistical analysis was performed by the chi-square test.

Results and discussions

In relation to results of evaluation from the efficiency of different models of composition of filters, in chart 2 are represented the total numbers of each contaminate agent that went through the filter and collected in samples of filtered water.

It is possible to observe that through layers of filter 1, 13 contaminate agents passed, and from this total, 03 were from *Endolimax nana* cysts, 01 cysts of *Giardia lamblia*, 08 eggs of *Ascaris lumbricoides* and 01 larva of *Ancylostoma duodenale*. For the composition of filter 02 passed 11 contaminate agents, of which 07 were cysts of *Giardia lamblia*, 02 eggs of *Ascaris lumbricoides* and 02 larvae of *Ancylostoma duodenale*, and through the composition of filter 03 passed 03 cysts from *Endolimax nana* and 01 cyst of *Giardia lamblia*. Through evaluation of the specific efficiency of each models of filter composition in terms of contaminate agents, it was found that the differences were statistically significant only for the composition of the filter model 02, and the difference was for efficiency filtration of cysts nana Endolimax, whose quantity of agents that passed by the filter was statistically higher than the cysts of *Giardia lamblia*, and it doesn't have differences in relation to the other contaminate agents studied (Table 3).

When the static test was applied with the idea to compare the efficiency of filtration between the different models of filter composition, differences were observed in models of composition 01 and 03, being the composition model 01 the one which has shown miner efficiency than model 03, specially with eggs from *Ascaris lumbricoides* (chart 4). Crompton

Chart 2. Evaluation of the efficiency of different types of compositions of filters - total numbers and relative percentages of contaminate agents collected in samples of water after the passage of water from filters.

CONTAMINATE AGENTS	Filter model 1 PHASE		Filter model 2 PHASE		Filter model 3 PHASE		TOTAL
	1	2	1	2	1	2	%
	%	%	%	%	%	%	
Endolimax nana - cyst	28,57	16,67	100	33,33	100	50	**40,63**
Giargia lamblia - cyst	14,29	0,00	0	0,00	0,00	50	**6,25**
Ascaris lumbricoides - egg	57,14	66,67	0	33,33	0,00	0	**31,25**
Ancylostoma duodenale - larva	0,00	16,67	0	33,33	0,00	0	**9,38**
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Phase1: use of water with contaminate agents; phase 2: use of non-contaminated water

Chart 3. Through evaluation of specific efficiency of each model of composition of filter related to different contaminate agents.

Filters	x^2	*g*	*p*	*Significance* x^2
model 01	10,09	3	0,0178	*NS*
model 02	9,73	3	0,00109	** E. nana e Giardia*
model 03	6,0	3	0,1115	*NS*

² =Chi-square test ***NS****= non-significant* ** Significant p < 0,01*

Chart 4. Evaluation from efficiency of filtration from models of filter composition related to different contaminated agents.

CONTAMINATE AGENTS	x^2	g	p	*Significance* x^2
Endolimax nana – cyst	2,47	2	0,2915	*NS*
Giargia lamblia - cyst	1,00	2	0,6065	*NS*
Ascaris lumbricoides - egg	10,41	2	0,0055	* between filters 1 and 3
Ancylostoma duodenale - larva	2,01	2	0,3677	*NS*

X^2 = Chi-square test ***NS****= non-significant* ** Significant p < 0,01*

(1988) and Croll et al., (1982) described that *Ascaris* eggs are considerated common and difficult to remove from contaminated soils.

Considering the data present in chart 1, it is possible to observe that cysts from *Endolimax nana* and *Ascaris lumbricóides* eggs, are the ones to present the most number of contaminate agents that went through the filters, in a total sum related to other studied parasites, and in this case, we stand the need to watch carefully the filtration process when the problem of contamination is associated to this contaminate agents.

In the other hand, it is evident that, to eggs from *Ascaris lumbricóides*, from a total of 10 parasites that went through the filters, 08 were collected in filter 01 and, in the case of *Endolimax nana* cysts from a total of 13 parasites, which went through the filter, 07 were collected in filter 02. This results indicate that, to these contaminate agents, the respectively filters should not be used, when comparing to other models on study.

With an analyze of data presented in chart 4, it is possible to see that the filters tend to keep the contaminate agents even when there's a constant flow of water after the contamination process, where the charging of contaminate agents, previously kept in the filters, presented extremely reduce values related to initial concentration used.

The performance of this process of passage of clean water through filters, makes possible to evaluate the safety of results, because of the high initial concentration of contaminate agents in water, the occurrence of an inconsistent retention through filters could be observed.

It is important to consider that, since the filters were set on boxes with a surface of 1,32m^2, the subsequent flow of 210 liters of water is a rainfall of approximately 160 mm slide, which occurred in a space time around 2 hours (time required for passage of all water through the filter), a total intensity of 80 mm hour-1, which is considered high. This fact shows that, results from efficiency of models of filter composition were gotten in test conditions highly demanding, related to the point of research.

Considering the results given in charts 1,2 and 3, it is possible to observe that, the filter from model 03 is the one to present higher capacity to a total retention of parasites comparing to other models, where, statistically the results were similar or superior to the other contaminate agents studied, emphasizing the effect on cysts of *Endolimax nana* and *Ascaris lumbricoides* eggs, which were the parasites to present a higher total number of agents that passed in the filters.

In this context, it is reasonable to say that, such behavior of the results checked could be associated

to the presence of pure clay replacing 50% of sand used in the filter. However, the results from chart 5 point to a big efficiency in the layer from clayed soil related to other layers from the filter. The presence of clay mixed with sand reduces the movement of water in the filter; in this case, the presence of this layer could have aggravated the effect of filtration from other layers, because it reduces the speed of flow of contaminated water, increasing the time of action in the filter. It is important to stand that, in the initial methodology was foreseen replacing the sand layer for pure clay, however, in the initial tests, this layer created a physical impediment to passage of water, significantly reducing the filtration process. Similar parameters were discussed by Di Bernardo (1993).

In terms of the effect of layers in an individual way about filtration, to the case of effect over the eggs of Ascaris lumbricóides, it was observed that, statically superior the effect in layer 02 was not followed by differences among other layers, indicating that the occurrence of an additive effect of filtration in a long passage of water through different layers of the filter.

The industrial sand presented a statically significant action, with a superior effect in relation to the intern layer of crushed stone in retention of *Ascaris lumbricóides* eggs and the layers with intern crushed-stone and TNT to retention of *Giárdia lamblia* cysts. This result is important, because the industrial sand presents more granulometria than the sand of river used in the adjuvant layer and, in that way, could present inferior results of retention. Until a determinate limit of effect of retention could be associated to a better adjustment between the particles and a minor movement duo charging by liquid, because of a higher density of this material with the river sand.

With an evaluation from the effect of layers from filters composition in relation to contaminate agents, it was observed that layer 02 (clay soil) was the one to present in general, a better capacity to filtrate. Meanwhile, this result is consistent, because it is the first layer to have contact with contaminate material, and in that way, performs the job to retain due to the higher number of parasites present, when the contaminate water reaches this layer; this demonstrates the filtration effect of soil in terms of these agents.

From all contaminate agents evaluated, the cysts of *Giardia lamblia* and of *Ancylostoma duodenale* larvae were the ones to be retained in a higher rate on filters (chart 1). Being observed in minor number in samples after the passage of contaminate water through the process of filtration, however, the statistical results do not express significant differences between the retention of different contaminants. Such fact should be associated to a low number of contaminants not retained in the filters, which makes difficult to have statistical inferences that are more decisive about the results checked. Thompson (2000) observed that the giardia is a microorganism of big presence in antropic environments and, in general, even though insipient studies of decontamination of soils, shows to be passive to control and eliminate, and similar aspects are described by por Asmi et al, (1970) to the ancilostomídeos.

Although results evidence some statistical significant differences among the models of filters

Chart 5. Evaluation of the effect of different layers of filter composition related to retention of different contaminate agents.

CONTAMINATE AGENTS	x^2	*gl*	p	(**) Layers with significante differences.	Significante diference according to the layer (**)
Endolimax nana – cyst	28,87	6	0,0001	(2 e 1), (2 e 4), (2 e 5), (2 e 7)	(p < 0,01), (p < 0,01), (p < 0,01), (p < 0,05)
Giargia lamblia – cyst	29,34	6	0,0001	(2 e 1), (2 e 5), (2 e 6), (4 e 5), (4 e 6)	(p < 0,01), (p < 0,05), (p < 0,01), (p< 0,01), (p< 0,01)
Ascaris lumbricoides - egg	46,34	6	0,0001	(2 e 1), (2 e 3), (2 e 4), (2 e 5), (2 e 6),(2 e 7), (4 e 5)	(p < 0,01), (p < 0,01), (p < 0,01), (p < 0,01), (p < 0,05), (p < 0,01), (p < 0,01)
Ancylostoma duodenale - larva	15,1	6	0,0195	***NS***	***NS***

^{2} =*Chi-square test* ***NS***= *non-significant*

evaluated, it should be consider that both presented high efficiency to retain all the contaminate agents that were studied, which final results show that, after the filtration process all samples of water presented patterns that are included in the class of drinkable water, according to patterns establish by Order 518/2004 from The Health Department (BRASIL-MS, 2004). In terms of how important is the process of filtration of water Barcellos et al, (2006) concluded that, in the rural communities studied, the use of water from shallow wells to domestic use, animal use and to irrigate crops is not recommended without proper treatment. In this condition, it can be said that, a filtration with the processes studied in this project, can serve as a tool to compose parts of process of treatment of contaminate waters.

The tests show that, the use of filters composed by layers of associated materials, such as crushed Stone, Clay soil, industrial sand, tissue and non-tissue TNT and sand + pure clay in different combinations represents an efficient alternative to remove the parasites Endolimax nana, Giardia lamblia, Ascaris lumbricoides and Ancylostoma duodenale when present as contaminate agents of water.

Among the combinations of filters studied, the one to present the passage in a minor index of contaminate agents during the process of filtration, was the one that use the presence of layers from 50% of associated sand with 50% of pure clay in the place of use of tissue non-tissue TNT, and should be preferred because it is an abundant material in nature and independent of an industrial process, like TNT.

The contaminate agents Endolimax nana cysts and Ascaris lumbricoides eggs – were the ones to present more problem to filtrate, and presented the higher signs of presence in samples after they went through the filtration process.

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