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Water footprint analysis as an indicator of sustainability in non-conventional drinking water treatment systems

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Abstract
The impact of multiple-stage filtration (MSF) was determined in two study systems. Water footprint (WF) was estimated with all its components and their results allowed the identification of those responsible for the environmental impact associated with drinking water production. Climatic conditions of high and low precipitation and socio-cultural context were considered. Results showed technical shortcomings, such as the presence of fissures that generate losses and the contribution of polluting substances in the effluent from filter washing. Socio-economic limitations increase the WF. Water management can be improved by studying the WF components and their relationships with the socio-cultural component.

Keywords: water footprint; rural water supply systems; colombian andean basin; non-conventional drinking water treatment systems and multiple-stage filtration-MSF.

Análisis de la huella hídrica como indicador de sostenibilidad en sistemas de tratamiento de agua potable no convencionales

Resumen
El impacto de la filtración en múltiples etapas (MSF) se determinó en dos sistemas de estudio. La huella hídrica (WF) se estimó con todos sus componentes y sus resultados permitieron identificar a los responsables del impacto ambiental asociado con la producción de agua potable. Se consideraron las condiciones climáticas de alta y baja precipitación y el contexto sociocultural. Los resultados mostraron deficiencias técnicas, como la presencia de fisuras que generan pérdidas y el aporte de sustancias contaminantes en el efluente del lavado del filtro. Las limitaciones socioeconómicas aumentan la WF. La gestión del agua se puede mejorar estudiando los componentes de WF y sus relaciones con el componente sociocultural.

Palabras clave: huella hídrica; sistemas de abastecimiento de agua rural; cuenca andina colombiana; sistemas de tratamiento de agua potable no convencional y filtración en múltiples etapas-FIME.

1. Introduction

The water footprint (WF) is a sustainability indicator that measures total volume of freshwater consumed by human activities by a specific unit under study, which can be an individual, a crop, a geographically defined area, or a country [1]. The WF is subdivided into three components: green water footprint (WF_g), which is the total volume of water consumed from precipitation; blue water footprint (WF_b) component, which corresponds to the consumption of water from surface and aquifer sources; and grey water footprint (WF_{gr}) component, which refers to the amount of water

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needed to dilute the most impacting polluting agent in the water used during the production process [4-15].

This indicator allows for the identification of the impacts on water resources caused by the consumption habits of population groups in specific geographical locations [2]. In this manner, the results are oriented to the appropriation of basic concepts by key social groups [15], leading to daily practices transformation associated with the water resource - society relationship. To improve, the water use inside homes.

The WF concept and Water Footprint Assessment (WFA) have gained attention in water management discussions of productive sectors and integrated water resource management [9]. On drinking water sector is necessary to provide services directed at maximizing the efficient use of resources and generating less waste [20]. Considering drinking water like a product, their WF could show the freshwater consumption volume used and polluted to produce the final product: drinking water. Moreover, the WFA provides insight to improve the production process [8]. Despite the attempts to incorporate the concept in integrated analyses of drinking water supply systems, considering the drinking water like a product, no studies have been conducted that have introduced the WF concept in sustainability analyses of a drinking water treatment plant, and less to non-traditional drinking water supply systems, such as multiple-stage filtration (MSF); that are primarily implemented in rural areas.

Regarding non-conventional systems, MSF consists of dynamic gravel filters (DyGF) followed by up flow gravel filters (UGF), and finally slow sand filters (SSF) [17,22] that are coupled together. This coupling of gravel and sand filters provides an alternative and robust treatment for surface water sources with variable water quality in rural communities at low operation and maintenance costs [14]. This treatment method can be operated and maintained by personnel with basic technical knowledge. It produces water that satisfies drinking quality standards, only requiring disinfection to provide safe water, and can be administered by community-based management boards, thereby generating social benefits to communities by providing access to drinking water [5]. MSF technology, as other drinking water treatment systems, presents effluents from filter washing; which can have an impact on the receiving sources of the discharges, generated during the maintenance process.

In 2016, there were 2,802 registered community-based companies that provided water supply services to rural areas of Colombia, these companies are generally community organizations authorized by the state [17]. However, unofficial data indicate that more than 12,000 community organizations that provide domiciliary public services, which supply drinking, water to approximately 40% of the rural population in the country. The communities created these organizations to solve problems that either the state or the market has not managed to solve. In addition, these organizations have water supply systems that have survived continuous administrative and political reforms [21]. The majority of these organizations do not report data on their operation, management, and administration and subsequently, challenges evaluation in terms of sustainability due to lack indicators. In this sense, the sustainability of water supply systems is a key factor when evaluating its implementation and consequent monitoring. This evaluation is performed by evaluating changes in the quality of service provided over time [12]. When service is considered sustainable, the quality remains constant and even improves.

Sustainability analysis of MSF should consider the socio-economic and cultural conditions of communities, likewise the uses, management, operation and maintenance of the water treatment system. Hence, the requirement to define indicators for sustainability has been highlighted in recent decades to provide a solid basis for decision-making at all levels and to contribute to environmental sustainability and integrated development [19]. In addition, it is necessary to obtain information to determine the sustainability of complex systems, such as rural community water supply systems [18].

In this scenario, WF emerges as an indicator of sustainability that allows identification of the cause and effect relationships of production systems, with socio-economic activities being the main factor of human pressure on natural resources [15]; in this case, water is considered as a basic consumption service. Accordingly, the objective of this research was to use the WF as an indicator of sustainability during the analysis of drinking water treatment systems, such as the MSF-based systems, in two rural study areas in Colombia.

2. Methods

2.1. *Study areas*

The selected study areas were two drinking water treatment systems that met the following specific criteria: i) supply with drinking water that fulfils the quality standards established in Colombia ii) destocking drinking water risk by water scarcity, climate change, and population growth. Both study areas have MSF technology, supplying rural populations, and are managed by community-based boards.

The two MSF systems are located in south-western Colombia, specifically in the Cauca River Basin. These systems are MSF of Mondomo (Cauca Department) and MSF of Golondrinas (Valle del Cauca Department). Mondomo is located in the south of the municipality of Santander de Quilichao, in the basin of the Mondomo River, on the right bank of Cauca River (Fig. 1). The MSF system of Mondomo is at 1,350 metres above sea level and supplies 802 users. This MSF, supplied by San Pablo stream, is comprised of four DyGF, four UGF, and four SSF and produces between 810 to 1,254 m^3 of drinking water per day.

Golondrinas is located in the north of Cali city, which is in rural area of Aguacatal River Basin, on the left bank of Cauca River (Fig. 1) at 1,661 metres above sea level; the system supplies 3,500 users. El Chocho stream supplies this MSF system, and is comprised of two clarifiers, two DyGF, two UGF, and four SSF; the system produces from 319 to 518 m^3 of drinking water per day.

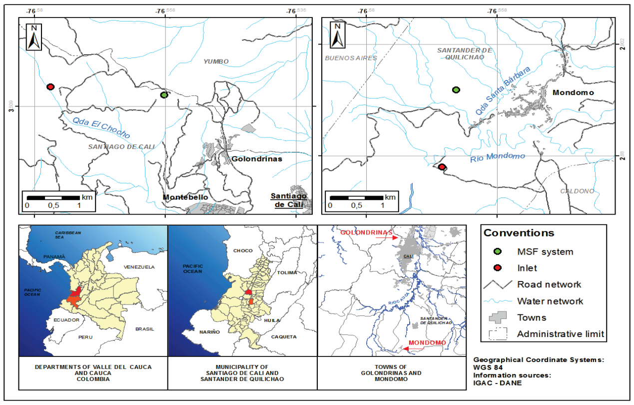

Figure 1. Locations of the study areas.
Source: The Authors.

2.2. *Climatic conditions*

Precipitation analysis was performed within each basin using the information from the two closest pluviograph stations to each study area; in Mondomo, the Mondomo Station was selected, with records for 47 years (1967-2014), and in Golondrinas, the Villa Araceli Station was selected, with records for 32 years (1981-2013). The information processing allowed the selection of months with high and low precipitation.

2.3. *Water footprint estimation*

The WFs of drinking water production in the MSF systems of Mondomo and Golondrinas were estimated for each of the three components: green, blue and grey. Moreover, estimates are obtained for each component, in two climatic conditions corresponding to the months that on a multi-year monthly average had the highest and lowest precipitation in each case.

First, the WF_g was estimated as the product of multi-year monthly mean precipitation of the month under study, according to climatic condition and surface area of all the water bodies of each MSF (Eq. 1).

$$WF_g = \frac{\sum Volume\ of\ water\ collected\ from\ precipitation}{Production\ of\ treated\ water} \quad (1)$$

The WF_b is subdivided into the following: the volumes evaporated, produced, accumulated, lost by fissures, and used in washing water (Eq. 2). The volume of evaporated water ($V_{Evaporated}$) is estimated as the product of the multi-year monthly mean evaporation of the selected month according to climatic condition under study and the water mirror area. The volume of water produced ($V_{Drinking}$) was obtained from the macro measurement records of the MSF systems. The volume of accumulated water ($V_{Accumulated}$) was estimated using the geometry of the ponds measured in the field. In the units without filters, the wet depth of the structure was measured; in the filters, the total wet depth was estimated as the sum of the depth measured from the top of the filter bed to the surface of the water and the depth of the bed according to the designs; knowing the theoretical porosity at which this type of filter is built, the volume of accumulated water was estimated as the difference between the total wet volume of the filter and the volume occupied by the filter bed. The volume of water lost due to fissures (V_{Lost}) in different parts of the filters was calibrated in the wash water outlet chambers of the two study cases. The volume of water used in the washings (V_{Wash}) was estimated as the product of the flow used to wash each unit of treatment or each m^3 of sand in the case of SSF multiplied by the lasting of the washing work and the number of times this work is done every month, whether it is high or low precipitation.

$$WF_b = \frac{V_{Evaporated} + V_{Drinking} + V_{Accumulated} + V_{Lost} + V_{Wash}}{Production\ of\ treated\ water} \quad (2)$$

The WF_{gr} was estimated as the quotient of the water quality difference from inlet to outlet of the MSF treatment units and the relationship between quality of the water in the receiving source of the discharge in relation to the quality objectives of the source, all this multiplied by the discharge flow of the MSF (Eq. 3). The quality objectives are established by the corresponding environmental authorities; accordingly, the limits considered in the case studies were the following: dissolved oxygen (DO)> 4 mg/L, biochemical oxygen demand (BOD_5) <10 mg/L, total suspended solids (TSS) < 25 mg/L and faecal coliforms < 20,000 CFU/mL [11].

$$WF_{gr} = \frac{\left(\frac{C_{effl} - C_{affl}}{C_{max} - C_{nat}} * Effl\right) * T}{Stage\ Product\ production} \quad (3)$$

Where (C_{max}) is the maximum concentration of pollutants accordingly to the river quality objectives, (C_{nat}) is the concentration of pollutants in the water source before receiving discharges, (C_{afl}) is the concentration of pollutants at the beginning of the stage, (C_{effl}) is the concentration of pollutants at the outlet of the stage, (Effl) is the flow of the stage and (T) is the time at which the discharges occur.

Water quality monitoring was conducted in July with the lowest precipitation and in May with the highest precipitation, taking samples of i) the water used for washing, ii) the water effluent from washing of each of treatment units of MSF systems (dumping) and iii) the source of the discharges. In the samples taken, quality parameters that have already established quality objectives were analyzed in the laboratory. WF_{gr} were estimated for each of the quality parameters analysed, and only the greater quantity of each treatment unit was selected. Finally, total water footprint is the sum of total green, blue, and WF_{gr}.

3. Results

The values of WF components were considered to analyse the results; in the same manner, their relationships to the behaviours of environmental, technical and social variables were considered to explain the results. This analysis is the part of sustainability analysis that allowed integration of the three above-mentioned components with the WF results, enabling more robust analysis. Table 1 shows the relationship between footprint components and components that were analysed.

3.1. Climatic conditions

The precipitation histogram was obtained from the analysis of the climatic data (Fig. 2) from the two selected pluviography stations (Mondomo and Villa Araceli). The precipitation monthly mean multiannual is greater in Mondomo (166 mm) than that in Golondrinas (120 mm). The months of greatest precipitation in Mondomo are March (211 mm), April (213 mm), October (219 mm) and November (270 mm), and in Golondrinas, they are April (184 mm), May (163 mm), October (166 mm) and November (160 mm). The months of lowest precipitation in Mondomo are June (95 mm), July (78 mm), August (74 mm) and September (106 mm), and in Golondrinas, they are January (82 mm), February (87 mm), July (61 mm) and August (63 mm).

Table 1.
Methods used in the study area

Water footprint component	Relevant characteristics that affect the footprint	Variable to analyse
Green water footprint	Climatic variability of the area	Seasonal change
Blue water footprint	Drinking water characteristics of the production system; system design and maintenance variables	System operation, maintenance, and administration
Grey water footprint	Pollution derived from the system that is related to the care of the source of supply and its maintenance	Environmental management and care of the basin

Source: The Authors.

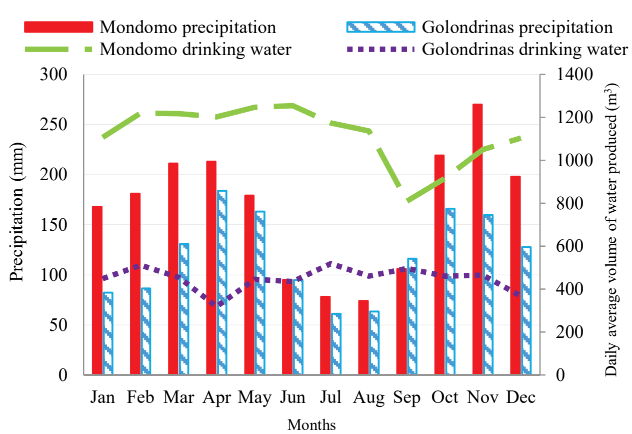

Figure 2. Histogram and drinking water volume produced by the MSF system under study.
Source: The Authors.

3.2. Water production per system

Two samplings were performed in the two systems for the periods of high and low precipitation between the months of May (high precipitation, 179 mm) and July (low precipitation, 61 mm). The conditions for the estimation of the WF components were determined in the field visits and a review of the data supplied by the system operators (Table 2). The annual mean daily water production was 1,119 m^3 in Mondomo and 449 m^3 in Golondrinas, i.e., Golondrinas produces 41% of the drinking water produced in Mondomo.

Table 2.
Mean daily water production in the Mondomo and Golondrinas systems for each month of the year

Month	Mean daily water production Mondomo (m^3)	Mean daily water production Golondrinas (m^3)	% differences in the mean daily water production
Jan	1,106	449	40.5
Feb	1,219	511	41.9
Mar	1,217	455	37.4
Apr	1,202	319	26.5
May	1,247	446	35.8
Jun	1,254	436	34.7
Jul	1,173	518	44.2
Aug	1,136	461	40.6
Sep	810	496	61.3
Oct	916	461	50.4
Nov	1,050	465	44.3
Dec	1,104	368	33.3
Mean	1,119	449	41

Source: The Authors.

Table 3.
Conditions for estimating water footprint components

Variable	High precipitation		Low precipitation	
	Mondomo	Golondrinas	Mondomo	Golondrinas
Production (m^3/day)	1050.4	319.1	1135.9	518.4
Chambers water surface area (m^2)	11.8	14.3	11.8	14.3
DyGF water surface area (m^2)	27.1	11.5	27.1	11.5
UGF water surface area (m^2)	91.2	46.5	91.2	46.5
SSF water surface area (m^2)	343.3	193.0	343.3	193.0
Lost water flow by fissures and others (L/s)	0.1	0.6	0.1	0.6
Inlet washing and DyGF water flow (L/s)	3.7	5.8	3.7	5.8
Water flow used in UGF washing (L/s)	4.9	4.3	6.7	4.3
Water flow used in sand washing (L/s)	1.5	1.3	1.5	1.3
Inlet and DyGF washing period (hours)	1	0.5	1	0.5
UGF washing |periods (hours)	4	4	8	4
Sand washing period (hours)	13	3	13	3
Number of times inlet and DyGF are washed per month	16	16	8	8
Number of times UGF is washed per month	6	6	2	2
Number of times sand is washed per month	1	1	0.3	0,3
Precipitation (mm)	270	184	74	61
Evaporation (mm)	106	75	132	90

Source: The Authors.

The technical and maintenance conditions of each of the systems (Table 3) were used to estimate the different WF components (Table 4) using Eqs. 1, 2 and 3.

For the WFgr calculation, BOD_5 and TSS were determined in the laboratory. The results showed that the Mondomo system generates more pollutant load than the Golondrinas system (Table 5).

The WFs were calculated under conditions of high and low precipitation (Table 6). The results showed that with high precipitation, the amount of water consumed or the WF is greater in the Golondrinas system (9.05 m^3/m^3 of drinking water) than that in the Mondomo system (4.84 m^3/m^3 of drinking water). In conditions of low precipitation, the WF of the Mondomo system is higher (3.01 m^3/m^3 of drinking water) than that of the Golondrinas system, which produces 2,67 m^3/m^3 of drinking water.

In all cases, the WF_{gr} represents the highest percentage among the components of total water footprint (Fig. 3), with values that exceed 50% of the total. In conditions of high precipitation, the WFs are higher in both systems, especially in Golondrinas, with a total water footprint of 9.0 m^3/m^3 of drinking water. The WF_{gr} represents a contribution of 82% of this value.

Table 4.
Daily volumes of water consumed by green and blue water footprint components

Calculated volumes to estimate water footprint	High precipitation		Low precipitation	
	Mondomo	Golondrinas	Mondomo	Golondrinas
Green water footprint estimation				
Precipitation volume at inlet (m^3)	0.11	0.09	0.03	0.03
Precipitation volume at DyGF (m^3)	0.24	0.07	0.06	0.02
Precipitation volume at UGF (m^3)	0.82	0.29	0.22	0.09
Precipitation volume at SSF (m^3)	3.09	1.18	0.82	0.38
Blue water footprint estimation: evaporated volume				
Evaporation volume at inlet (m^3)	0.04	0.04	0.05	0.04
Evaporation volume at DyGF (m^3)	0.10	0.03	0.12	0.03
Evaporation volume at UGF (m^3)	0.32	0.12	0.39	0.14
Evaporation volume at SSF (m^3)	1.22	0.48	1.46	0.56
Blue water footprint estimation: produced drinking water volume				
Volume of produced water in the MSF (m^3)	1,050.4	319.1	1,135.9	518.4
Blue water footprint estimation: accumulated volume				
Inlet accumulated volume (m^3)	1.95	4.32	1.95	4.32
DyGF accumulated volume (m^3)	13.21	3.34	13.21	3.34
UGF accumulated volume (m^3)	82.12	25.60	82.12	25.60
SSF accumulated volume (m^3)	302.08	81.07	302.08	81.07
Blue water footprint estimation: volume of lost water by fissures				
Volume of lost water in the MSF (m^3/day)	11.63	48.09	11.63	48.09
Blue water footprint estimation: washing water volume				
Wash water volume in the DyGF (m^3)	7.01	5.53	3.39	2.68
Wash water volume in the UGF (m^3)	14.17	12.52	12.37	4.04
Wash water volume in the SSF (m^3)	2.27	0.46	0.73	0.15

Source: The Authors.

Table 5.
Variables used to calculate the grey water footprint

Variable	High precipitation		Low precipitation	
	Mondomo	Golondrinas	Mondomo	Golondrinas
Flow rate (L/day)	1,050.4	319.1	1,135.9	518.4
BOD_5 (mg/L)	2	1	4	0,26
TSS (mg/L)	16	21	2.3	8
BOD_5 load (kg/day)	0.0021	0.0003	0.0045	0.0001
TSS load (kg/day)	0.0168	0.0067	0.0026	0.0041

Source: The Authors.

Table 6.
Water footprints of both systems in conditions of high and low precipitation

	High precipitation		Low precipitation	
Water footprints (m^3/m^3 drinking water)	Mondomo	Golondrinas	Mondomo	Golondrinas
Green water footprint	0.004	0.005	0.001	0.001
Blue water footprint	1.4	1.6	1.4	1.3
Grey water footprint	3.4	7.5	1.6	1.3
Total water footprint	4.8	9.0	3.0	2.7

Source: The Authors.

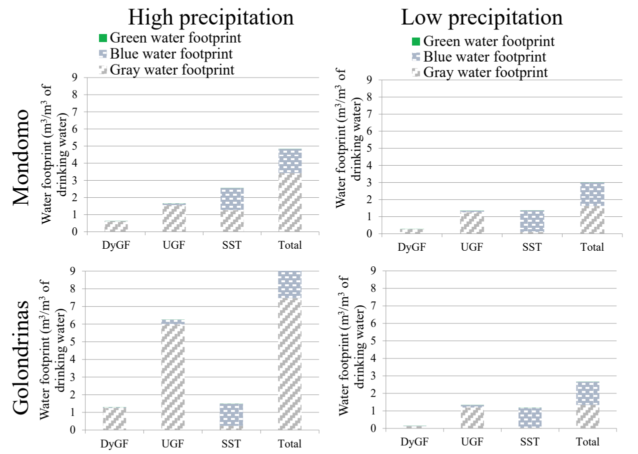

Figure 3. Water footprint in conditions of high and low precipitation in Mondomo and Golondrinas MSF.
Source: The Authors.

4. Discussion

Climatic conditions are the determining factors of the WF for the periods of low and high precipitation, with differences found in the total water footprint and the WF components for both systems [12-15]. In particular, the WF_b dynamics depends on evaporation, and the WF_g was directly affected by precipitation [7,8,2]. These two components depend on their calculation method, considering the water mirror area exposed in the systems, both of which are affected by precipitation and evaporation.

Precipitation directly affects the availability of water for both systems, allowing for an increase in the production of drinking water, in terms of the volume (m^3) per day (Tables 1 and 2). For Mondomo, the production went from 1,050.4 m^3/day in the low precipitation season to 1,135.9 m^3/day in the high precipitation season. This increase is not caused by the demand for drinking water by users, but by the demand for water from the industrial sector of cassava starch production [6]. During the low precipitation season for the Golondrinas system, the water production was 319.08 m^3/day, and in the high precipitation season, it was 518.39 m^3/day. This production is low, considering that the number of users of this system is four times higher than in Mondomo. Given that the source experiences drought conditions during the low precipitation season, the water produced in Golondrinas is not sufficient to meet the demand, which is only for human consumption. This scarcity of water means that public services companies of the district must supply the service to the sectors every 2 or 3 days, and during periods of drought, is implemented water rationing for up to 9 days. This result shows that the particularities of the system in each study area (Tables 2 and 3) and the socio-economic conditions influence the estimations of the WF components and the total value of the WF.

4.1. Green water footprint

WF_g represents less than 0.1% of the total water footprint (Fig. 3); this low proportion reflects the low human use of water from precipitation, that would reach the basin if the treatment process was not conducted using the large filters of an MSF system. This WF depends on the greater volume of accumulated precipitation during the treatment processes; this volume is a function of the area (473.41 m^2 in Mondomo and 265.42 m^2 in Golondrinas). The Golondrinas MSF is smaller (265.42 m^2) than the Mondomo MSF (473.41 m^2). However, the WF_g was higher in Golondrinas during high precipitation because the water production is four times lower (319 m^3/day) than that in Mondomo (1,050 m^3/day). Despite these differences, the effects of the WF_g are not significant compared to the total water footprint; as a result, the mechanisms to reduce it are not viable and influential in the WF sustainability analysis.

4.2. Blue water footprint

The WF_b for both systems presented similar behaviours. The value of WF_b is mainly dependent on the accumulated volume of water in the filters and has a lower contribution to both the lost volume of water due to fissures and the washing water volume (Table 4). Given the sizes of the filters, more water accumulates in the SSF, followed by the UGF. Because the Mondomo MSF is larger than the Golondrinas MSF, its volume of accumulated water is greater, 399.36 m^3, compared to that of Golondrinas (114.33 m^3). Although this volume of water is not available to the ecosystems in the basin natural consumption, it is a quantity of water that the population requires as drinking water; therefore, reducing the volume of accumulated water would only reduce the capacity and possibly the efficiency of the MSF, putting the water supply to users at risk.

Alternatively, Golondrinas MSF showed greater fissures in the filter tanks, generating water losses of 48.1 m^3/day, which is an aspect that influences the lost volume of water calculation, unlike the Mondomo system, where losses due to fissures were 11.6 m^3/day. This aspect is related to the age of the system and the work of management and administration of the company providing the public service, as they are responsible for the operation and maintenance of the MSF and, in general, the supply system. The socio-economic dynamics of the districts affect the work of the community-based organisation [10] according to aspects such as the lack of interest, sense of belonging, motivation and/or technical knowledge on behalf of the community-based board. This increases the problems in the supply system and consequently generates greater pressure on water resources, as the resource is not used efficiently. Likewise, the population could relate other aspects that could reduce the impact of this WF to the inefficient use of water because the lack of environmental culture generates more pressure in the system, thereby increasing the demand and the requirements of drinking water for provision.

4.3. Grey water footprint

WF_{gr} is the largest component in both systems, representing more than 50% of the total water footprint in both precipitation conditions. UGF constitutes 45 to 50% of the total water footprint in low precipitation conditions and from 34 to 69% in high precipitation conditions, given that high precipitation means that the water that reaches the MSF system contains surface runoff water with high loads of organic matter represented in TSS and faecal coliform contents. WF_{gr} presented in Mondomo corresponds to the reduction in the dissolved oxygen of the inlet and outlet in each treatment unit, as well as in the Golondrinas UGF during high precipitation conditions and the corresponding reduction in the UGF and the SSF during low precipitation. However, in Golondrinas, WF_{gr} also corresponds to the increase in the number of faecal coliform colony forming units in the DyGF and the SSF in high precipitation condition. For low precipitation, in addition to the reduction in OD, WF_{gr} in Golondrinas corresponds to an increase in BOD_5. Because the main factors of increase in WF_{gr} are associated with the reduction in OD from water used in treatment units washing, aeration processes of washing effluent can contribute to reduce WF_{gr} along with the flow of water used in the washing.

Likewise, the climatic condition of the area affects WF_{gr}, being lower in periods of low precipitation, because of the effect of basin washing that contributes to pollution on the water quality of the supply sources, resulting in a higher concentration of suspended solids in the water [3]. In addition, the water used in washing comes from the same supply source; therefore, it has lower quality than the supply used in conditions of low precipitation. The greater water footprint in high precipitation season is also associated with greater frequency of washing because the water of the supplying source is more polluted (38 to 84% more load of TSS in high precipitations), causing the filters to saturate faster; therefore, the frequency of washing is almost twice that in conditions of low precipitation.

The high value of WFgr of Golondrinas and Mondomo is related to the subsistence productive activities that are developed upstream of the MSF intake. In Golondrinas, the sanitary inspection in the upper area of the micro-basin showed that the main productive activities are associated with agricultural activities. For example, the tillage of the land is performed for flat zone conditions, ignoring the topography and slope of the mountainous area where the district is located; this activity brings sediment towards the channel [3]. Moreover, during the transition period between low and high precipitation, the effect of soil washing can drag of sediments to the stream, thereby generating turbidity peaks and increasing the concentration of pollutants that enters into the MSF, measured as suspended solids. This situation also occurs in Mondomo, considering that the drag of sediments is associated with the construction of tertiary roads near the intake.

In this sense, it is highlighted that the techniques used in the development of agriculture and human involvement in the upper area of the micro-basin have a negative effect on the production of drinking water, in addition to the discharge of domestic wastewater in smaller proportion that contribute to directly or indirectly contamination of both soil and water. Moreover, the morphometric characteristics of this micro-basin determine that it is an area with a strong erosion tendency and a torrential basin of short concentration times [16]; this situation favours dragging by runoff from eroded and contaminated soils that alters the water quality.

Given that WF_{gr} is the factor that contributes the most to total water footprint, it is necessary to analyse how to reduce its impact, thereby improving the technical aspects in the operation of the MSF. Filter washing is an example of an activity that influences the WF_{gr} calculation that must be analysed because an excess in the flow is required to complete it is cleaning in the absence of a complete washing of the filter on a regular basis. This influence in combination with the lack of training by the operator significantly increases the impact of the MSF on water consumption. In this sense, it is essential to perform constant training in issues related to the operation and maintenance of the system [19], [10], and the implementation of control and surveillance by public services companies.

5. Conclusion

Sustainability analysis is based on the calculation of each WF component, allowing for the identification of the critical aspects in environmental, technical and socio-cultural areas of a water supply basin. As a result, integrated management of water resources can be improved by studying the WF components doing a WFA. In the two study areas, the total water footprints of the systems only show that the systems consume more water from the natural system for production of drinking water (social demand). Alternatively, during the analysis of the component that significantly affects the total water footprint, the washing of filters and the losses of the system were determined as the technical factors that affect water sources in terms of pollution and loss of water resources, as reflected in the pressure of the system by sources with high water quality. Therefore, variables such as administrative management and the operation and maintenance of the system are reflected in the calculations of WF components; hence, the importance of having an integral view when incorporating the concept of WF becomes relevant.

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