Data Article

Experimental data of the laboratory investigation for the design of a new filter cartridge for water treatment

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\textbf{ABSTRACT}

The data provided here refers to the experimental laboratory investigation conducted in the Laboratory of Environmental and Maritime Hydraulics (LIDAM) of University of Salerno, Italy, with the aim of developing a new filtering cartridge for water treatment capable of overcoming the main inconveniences shown by usual commercial cartridges. Specifically, the proposed filtering cartridge is an economic, non-toxic, low-resistance and long-life cartridge, currently under a patent pending status, whose main advantage is to permit to significantly reduce, compared with the commercial cartridges, average head losses induced by the cartridge even for high clogging degrees, and to increase, as a consequence, the life cycle of the cartridges.

In this article a collection of pictures is provided, showing the different filters progressively tested in the laboratory, also in sand clogging conditions, until finding the optimal solution.

Pictures of the laboratory equipment, with adopted materials and instrumentation, are also given. Finally, tables with the values of the local pressure drops at the cartridge in the different test conditions are provided.

The data is related to “A new cost effective, long life and low resistance filter cartridge for water treatment” [1].

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Specifications table

| Subject area | Engineering |
|--------------|-------------|
| More specific subject area | Hydraulics |
| Type of data | Table, image |
| How data was acquired | - water levels in different system sections were measured with five piezometers, (Fig. 1);  
- the flow rate was measured with the GSD 8/20 volumetric flow meter (Qmax = 4 m³/h), by B Meters S.r.l. (Gonars, UD, Italy) (Fig. 2a);  
- the amount of sand to be progressively introduced into the filters to clog them was weighted by the SF-400 balance (Fig. 2b);  
- the pressure drops at the filter were measured twice, with two piezometers placed upstream and downstream of the filters for water levels below 2 m and with the 0–7 bar electronic differential manometer Digitron 2023P (Fig. 2c), 0.15% absolute accuracy (Fig. 3) |
| Data format | Analyzed |
| Experimental factors | The materials used to build the proposed filters are marble pebbles, EM ceramic and activated carbon cleaned before each carried experiment. |
| Experimental features | The hydraulic circuit consists essentially of: a polyethylene tank with capacity of 300 l, an electronic pump (maximum head 6.9 m, flow rate 0.4 ÷ 3.3 m³/h), a galvanized steel pipe with diameter φ¾”, two multilayer pipes linked in parallel with diameter φ 16 and φ 20, respectively, a single-jet water meter, a housing element with interchangeable filter cartridges. |
| Data source location | Via Giovanni Paolo II, 132, Fisciano (SA), Italy |
| Data accessibility | Data with this article |
| Related research article | S. Evangelista, G. Viccione, O. Siani, A new cost effective, long life and low resistance filter cartridge for water treatment, Journal of Water Process Engineering, Elsevier, 27 (2019), pp. 1–14. [1] |

Value of the data

The data can be of use to the scientific community and the technology developers working on investigation in this field for various purposes:

- To better understand the specific experimental investigation steps;
- To develop different filter solutions;
- To identify and analyze different clogging mechanisms in the filters;
- To validate numerical models, as done for instance in [2];
- To make the values of the pressure drops produced by the filters available for comparison with further experimental and design studies.

1. Data

In this article a collection of photographs is provided, showing the laboratory equipment and instrumentation and the different filters progressively tested in the laboratory until finding the optimal solution. The new cartridge is made of a central element in inert cotton wrapped in a
cylindrical polypropylene support, similar to the commercial one but with the core protected by elements – such as white marble pebbles, effective microorganism ceramic cylinders and granular active coal – which, while ensuring a good hydraulic permeability, are capable of stopping much of the particles suspended in the fluid before they reach the cartridge causing its clogging. The different elements are inserted in each tested filter (Filters 1, 2 and 3) and finally combined in the proposed cartridge (Filter 4).

Photographs of the progressive clogging of the four cartridges with sand, in the tests aimed at evaluating the head losses produced by the filters in clogging conditions, are also provided, together with pictures of the laboratory equipment and details of the experimental materials and instrumentation. See Figs. 1–19.

Finally, tables with the values of the pressure drops at the cartridge in the different test conditions are provided. See Tables 1–3.

2. Experimental design, materials and methods

The laboratory hydraulic pilot circuit, designed and built in the LIDAM Laboratory at University of Salerno at the aim of calculating the local head losses produced by the filter [3,4], is shown in Fig. 1. It consists essentially of:

1) a polyethylene tank with capacity of 300 l;
2) an electronic circulation pump with maximum head equal to 6.9 m, EVOSTA model 40–70/130 distributed by DAB Pumps S.p.A., Mestrino, Italy (Fig. 4);
3) a galvanized steel pipe with diameter $\phi 3/4"$;
4) two rolled in parallel pipes in multi-layer material with diameter $\phi 16$ and $\phi 20$, respectively;
5) a housing element with interchangeable filter cartridges.

Fig. 1. Laboratory setup.
Fig. 2. Measuring instrumentation: a) volumetric flow meter GSD 8/20, Qmax = 4 m3/h by B Meters S.r.l.; b) SF-400 balance; c) electronic differential manometer Digitron 2023 P.

Fig. 3. Connection of the filtering cartridge to the circuit: a) derivations located upstream and downstream of the filter element b) plastic tubes for the connection of the inlets of the electronic differential manometer with the circuit.

Fig. 4. EVOSTA pump, model 40–70/130.
Fig. 5. Materials and elements of the filtering cartridge: a) lateral and b) top view of the container and its connector; c) elements protecting the cartridge core: marble pebbles, EM ceramic and active carbon, respectively (up), and wadding (below).

Fig. 6. Inert synthetic wadding cartridge: a) top and b) front view of the proposed PET filter cartridge and of a wire-wound one, respectively; c) and d) constructive steps of the PET cartridge.

Fig. 7. Progressive clogging of Filter 1 (marble pebbles) with 20 g of sand at a time from 0 to 80 g.
Fig. 8. Final clogging condition of Filter 1.

Fig. 9. Top view of Filter 1.

Fig. 10. Progressive clogging of Filter 2 (EM ceramics) with 20 g of sand at a time from 0 to 80 g.

Fig. 11. Final clogging condition of Filter 2.
**Fig. 12.** Top view of Filter 2.

**Fig. 13.** Progressive clogging of Filter 3 (active carbon) with 20 g of sand at a time from 0 to 80 g.

**Fig. 14.** Final clogging condition of Filter 3.

**Fig. 15.** Top view of Filter 3.
Fig. 16. Progressive clogging of Filter 4 (mixed elements) with 20 g of sand at a time from 0 to 80 g.

Fig. 17. Final clogging condition of Filter 4.

Fig. 18. Top view of Filter 4.

Fig. 19. Limit clogging filter.
Table 1
Experimental head losses (in mbar) produced by a progressively clogged commercial cartridge using sand with honey and food glue, respectively, for the three pump velocities.

| Clogging scenario | Sand [g] | Δp [mbar] | Clog with honey | Clog with food glue |
|-------------------|----------|-----------|------------------|---------------------|
|                   |          |          | V<sub>min</sub> | V<sub>inter</sub> | V<sub>max</sub> |
|                   |          |          | V<sub>min</sub> | V<sub>inter</sub> | V<sub>max</sub> |
| 0                 | 0        | 21.6     | 27.0            | 46.4               | 21.6           | 27.2            | 46.9            |
| 1                 | 20       | 24.3     | 28.9            | 49.8               | 24.5           | 29.3            | 51.3            |
| 2                 | 40       | 29.3     | 37.6            | 62.3               | 30.3           | 38.2            | 72.2            |
| 3                 | 60       | 36.3     | 43.1            | 74.3               | 44.6           | 52.8            | 87.5            |
| 4                 | 80       | 45.1     | 52.6            | 86.5               | 56.1           | 63.5            | 96.7            |

Table 2
Head losses produced by an inert synthetic wadding cartridge for increasing clogging rates with the three pump speeds.

| Fine sand [g] | Δp [mbar] |
|---------------|-----------|
|               | Minimum velocity | Intermediate velocity | Maximum velocity |
| 0             | 19.4       | 24.1       | 39.9       |
| 20            | 21.9       | 26.6       | 42.7       |
| 40            | 28.1       | 34.7       | 56.1       |
| 60            | 37.8       | 43.7       | 70.1       |
| 80            | 46.6       | 55.7       | 81.9       |
| 100           | 56.3       | 64.8       | 91.3       |
| 120           | 61.6       | 70.7       | 97.6       |

Table 3
Head losses (in mbar) for all the filters and for the three velocities in the circuit, respectively, and increasing clogging rates.

| Sand [g] | Filter 1 | Filter 2 | Filter 3 | Filter 4 |
|----------|----------|----------|----------|----------|
|          | V<sub>min</sub> | V<sub>inter</sub> | V<sub>max</sub> | V<sub>min</sub> | V<sub>inter</sub> | V<sub>max</sub> | V<sub>min</sub> | V<sub>inter</sub> | V<sub>max</sub> |
| 0        | 20.7     | 26.6     | 41.5     | 22       | 28.6     | 44.6     | 25.9       | 33.3     | 49.9     |
| 20       | 21.5     | 27.6     | 42.9     | 23.3     | 29.5     | 45.8     | 26.1       | 33.7     | 50.3     |
| 40       | 23.2     | 29.1     | 45.4     | 24.6     | 30.9     | 47.8     | 26.6       | 34.1     | 50.9     |
| 60       | 25.1     | 31.1     | 48.2     | 25.5     | 32.4     | 50.1     | 27         | 34.4     | 51.5     |
| 80       | 26.8     | 33.5     | 51.5     | 26.9     | 33.6     | 52.5     | 27.3       | 35       | 52.4     |
| 100      | 28.8     | 35.7     | 54.8     | 28.3     | 35.6     | 54.7     | 28         | 35.6     | 53.1     |
| 120      | 30.1     | 37.8     | 56.9     | 29.9     | 38       | 57       | 28.5       | 36.3     | 54.2     |
| 140      | 31.4     | 39.6     | 59.1     | 30.5     | 38.9     | 58.1     | 28.9       | 36.9     | 55.1     |
| 160      | 32.5     | 41.1     | 61       | 30.9     | 39.7     | 59       | 29.4       | 37.5     | 56.2     |
| 180      | 33.4     | 42.7     | 62.8     | 31.4     | 40.5     | 60.1     | 29.9       | 37.9     | 57.1     |
| 200      | 34.7     | 44       | 65.1     | 31.8     | 41       | 61.2     | 30.4       | 38.7     | 58       |
| 220      | 35.9     | 45.5     | 67       | 32.3     | 41.5     | 62.1     | 31.8       | 40.2     | 60.4     |
| 240      | 37.1     | 46.6     | 68.9     | 35.6     | 44.6     | 65.8     | 35.3       | 44.2     | 66       |
| 260      | 38.4     | 48       | 70.9     | 38.2     | 47.4     | 69.9     | 40.1       | 49.6     | 73.4     |
| 280      | 39.3     | 48.9     | 72       | 40.3     | 50.4     | 73.5     | 42.9       | 53.8     | 78.4     |
| 300      | 40.1     | 49.8     | 73.2     | 41.8     | 52.3     | 76.2     | 45.8       | 56.5     | 81.5     |

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The measuring instrumentation used in the experiments is the following:

- the five piezometers, to measure the water levels in different system sections (Fig. 1);
- the volumetric flow meter GSD 8/20, \( Q_{\text{max}} = 4 \text{ m}^3/\text{h} \) by B Meters S.r.l. (Gonars, UD, Italy) (Fig. 2a), to measure the flow rate in the circuit;
- the SF-400 balance (Fig. 2b), to accurately measure the amount of sand to be progressively introduced into the filters to clog them (20 g at a time to guarantee an appreciable variation in head losses recorded at each increment);
- the pressure gauge to independently measure the pressure losses (below 0.2 bar) at the filter with higher accuracy than with the two piezometers placed upstream and downstream of the filter, i.e. the 0–7 bar electronic differential manometer Digitron 2023P (Fig. 2c), with 0.15% absolute accuracy. This gauge is connected to the circuit by joining, with plastic tubes, its two inlets with two derivations located upstream and downstream of the filter element, respectively (Fig. 3), in order to evaluate the pressure difference between these points, which corresponds to the head loss due to the filter operation. More in detail, the pressure values correspond to the ensemble average of three measures taken in steady flow conditions.

More specifications about the methods adopted for the experiments are reported in [1,3,4].

In each test a filtering cartridge is inserted in the proper derivation and connected to the circuit and the corresponding locally produced head losses are measured. The material and elements used to make the filtering cartridge are reported in Fig. 5, where the lateral (Fig. 5a) and the top view (Fig. 5b) of the filter container and its connector are shown. In Fig. 5c it is possible to see the wadding and the elements used to protect the cartridge core: marble pebbles, EM ceramic and active carbon, respectively.

Fig. 6 shows the inert synthetic wadding cartridge: respect to the commercial cartridge, the first step was to make a new filter by replacing in the cartridge the polypropylene wire by PET cotton or synthetic inert wadding, for which the head loss exhibited by different clogging degrees and for the different pump velocities were evaluated. The wadding is wrapped around the polypropylene slashed supporting cylinder, as several layers overlapped with each other to create a spiral system capable of retaining even smaller particles. Fig. 6 shows pictures of a) top and b) frontal view, respectively, of the proposed PET cartridge compared with the classic commercial wire-wound one, as well as of steps of its building process (Fig. 6c and d).

Fig. 7 presents, instead, the first filter built in the laboratory, the one with inert synthetic cotton cartridge and white marble pebbles (Filter 1), specifically with a progressive clogging rate, obtained artificially obstructing the filter by adding 20 g of sand at a time in each test, from 0 to 80 g of sand, from the top with water permeated downwards inside the filter. The final clogging condition is shown in Fig. 8. A top view of Filter 1 is given in Fig. 9.

The progressive clogging of Filter 2, the one with inert synthetic cotton cartridge and EM ceramics, is reported in Fig. 10, with the final clogging condition in Fig. 11. A top view of Filter 1 is given in Fig. 12.

Similarly, Fig. 13 illustrates the progressive clogging of Filter 3, the one with inert synthetic cotton cartridge and active carbon, with the final clogging condition in Fig. 14 and details of the top view in Fig. 15.

Finally, in Fig. 16 the progressive clogging of Filter 4, the one with inert synthetic cotton cartridge and all the previous elements (marble pebbles, EM ceramics and active carbon) mixed up, with the final clogging condition in Fig. 17 and details of the top view in Fig. 18.

In Fig. 19 the limit clogging filter is illustrated, specially designed in the condition that all the available voids between the grains were occupied by the added sand, a cartridge identical to the previous ones but with only fine sand added in the space between the filter and the SAN glass, for a total of 800 g.
2.1. Filter pressure drops data

Table 1 provides the experimental data in terms of pressure drops in mbar obtained through a commercial wire-wound cartridge tested in different scenarios, i.e. for the three pump velocities, respectively, and for progressive clogging of the filter with 20 g of sand each time up to 80 g, using honey and food glue to ensure effective clogging of the sand, respectively.

Table 2, instead, contains the values of pressure drops in mbar obtained through a synthetic wadding cartridge tested for the three pump velocities, respectively, and for progressive clogging of the filter with 20 g of sand each time up to 120 g.

Finally, in Table 3 the values of pressure drops in mbar produced by the four new proposed filters for progressive clogging up to 300 g of sand the three pump velocities, respectively, are reported.

Transparency document. Supplementary material

Transparency document associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2018.12.025.

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