Multicriteria decision-aid method to evaluate the performance of stormwater infiltration systems over the time

Méthode d'aide à la décision pour le suivi au cours du temps de systèmes d'infiltration des eaux pluviales

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RÉSUMÉ

Les systèmes d'infiltration des eaux pluviales sont de plus en plus utilisés en raison de leur aptitude à réduire les débits et volumes d'eau apportés aux ouvrages situés en aval, à diminuer les rejets aux exutoires de surface ou encore à recharger les nappes. De plus ils se présentent sous des formes variées permettant de favoriser différents usages comme par exemple des terrains de sport inondables ou des bassins utilisés en jardins. Malgré ces avantages, leur comportement sur le long terme pose encore question. Leurs performances réelles doivent donc pouvoir être évaluées et ce en intégrant des aspects nombreux et parfois conflictuels. Pour avancer sur ce problème, un système d'aide à la décision est proposé. Il est basé sur une méthode multicritère construite pour aider les gestionnaires de tels ouvrages à évaluer la performance de systèmes existants tout au long de leur durée de vie et d'identifier si globalement ils fonctionnent correctement au vu de critères environnementaux, socio-économiques, techniques et sanitaires. L'article présente donc successivement : les indicateurs de performances choisis et leur mode de construction, la méthode multicritère permettant de se prononcer sur leur bon fonctionnement et une étude de cas.

MOTS-CLÉS :

Drainage urbain, indicateurs, méthode multicritère, systèmes d'infiltration

ABSTRACT

Nowadays, stormwater infiltration systems are frequently used because of their ability to reduce flows and volumes in downstream sewers, decrease overflows in surface waters and make it possible to recharge groundwater. Moreover, they come in various forms with different uses such as floodable sport grounds or basins used as gardens. Despite these advantages the long term sustainability of these systems is questionable and their real performances have to be assessed taking into account various and sometimes conflicting aspects. To address this problem a decision support system is proposed. It is based on a multicriteria method built to help managers of such systems to evaluate the performance of an existing infiltration system at different stages of its lifespan and identify whether it performs correctly or not according to environmental, socio-economic, technical and sanitary aspects. The paper presents successively: the performance indicators and the way they were built, the multicriteria method to identify if the system works properly and a case study.

KEYWORDS:

Indicators, infiltration systems, multicriteria method, urban drainage

1 INTRODUCTION

Nowadays, pipe networks developed to drain urban areas generate a large amount of storm run-off volume and pollution. They are responsible for frequent flooding and environmental problems that have important social and economic implications.

To solve these problems, infiltration systems are frequently used as an option to manage urban storm drainage. These techniques present important advantages:

- they reduce flows and volumes in downstream sewers or in surface waters;
- they limit wash-off phenomena in urban areas and consequently lead to a reduction of the pollutant load;
- they favor quantitative groundwater recharge by infiltration;
- they present an important treatment potential by settling;
- they allow urban development in areas far from surface outlets (existing networks or water courses);
- they come in various forms with different uses such as floodable sport grounds or basins used as gardens.

Despite these advantages, their long term sustainability is not certain. Numerous questions rise from their utilization. It involves flooding protection efficiency (considering its evolution over time with clogging phenomena), their effectiveness in environmental and public health protection, the groundwater pollution risk, the management of sediment trapped, social acceptance, costs ...

For these reasons, the evaluation of infiltration techniques is indispensable and the research of a compromise between their multiple facets is needed.

To address this problem a decision support system is proposed. It is based on a multicriteria method built to help designers and managers of such systems to: i) evaluate and compare the performance of alternatives or different projects at a design stage (choice of a good project among a set of alternatives), ii) evaluate the quality of an existing infiltration system and the strategies to be applied to improve their performance (choice of maintenance strategies, selection of technical/ social/ environmental improvements, choice of rehabilitation solutions, …).

The present article only deals with the second part of the problem aiming at evaluating if an existing infiltration system still works properly according to technical, environmental and socio-economic aspects. The decision support system developed to evaluate projects at the design stage has already been published in (Moura *et al.*, 2007a).

2 METHODOLOGY

The proposed method integrates both the evaluation of an existing system according to different indicators and the way to identify if a system has to be examined more particularly because of its suspected low performance at a particular stage of its lifespan.

The development of the method needs: i) the construction of performance indicators, ii) the test of the quality of each indicator, iii) the test of the quality of the global set of indicators, iv) the development of a multicriteria method to identify if the system works properly.

2.1 Construction of indicators

In order to evaluate existing systems a set of performance indicators integrating technical, economical, environmental, social and sanitary aspects was developed. The work was carried out with the help of a multidisciplinary working group and the support of the research federation OTHU (http://www.othu.org) gathered to develop a Field Observatory in Urban Hydrology situated in Lyon, France. The working group is composed of researchers from different fields (hydrology, biology, chemistry, environment, groundwater domain, soil science, social science) and professionals from public and private companies (designers, people in charge of maintenance or control of existing systems). The Field Observatory OTHU is used to get reliable information and knowledge from intensive on-site measurements. This observatory is quite useful to construct indicators and to test the assessment procedures proposed to model the performance indicators. The goals and their respective indicators are presented in the third part of the paper.

2.2 Test of the quality of each indicator and test of the whole set of indicators

For the evaluation of the quality of each indicator, criteria developed by Labouze & Labouze (1995) were used. Table1 shows the different criteria and the way each one was tested. When an indicator did not meet the requirements, it was re-defined until fulfilling an acceptable level of quality. All the tests can be found in Moura (2008).

Quality required for the indicator	Way of testing
Relevance (Does it correspond to a real aspect to verify?)	This quality is checked by the working group which is pluridisciplinary and involves different points of view.
Accessibility (Is the indicator easy to calculate and are the data for its calculation available at an acceptable cost?)	This quality is set *a priori* and then verified by applying the indicator to different contexts and case studies given by the professionals of the group.
Objectivity (Is it ambiguous? Can it be interpreted in the same way by different potential appraisers?)	The results of the indicator evaluation coming from case studies are submitted to different people who must interpret them in the same way.
Robustness (Does it give stable results according to the variation of uncertain parameters?)	The source of uncertainties was evaluated on real case studies. Taking into account the range of uncertainties, we considered the indicator robust when the results tend towards same tendencies.
Sensitivity (Does it discriminate different strategies or states properly?)	The indicator was found sensitive when it was capable to identify a difference between systems known to be different.
Fidelity (Can the indicator be estimated with a constant bias? Can it be evaluated in the same way by different appraisers?)	Different appraisers evaluate an indicator on real case studies, the tendency of the evaluation must be the same.
Univocity (aptitude to give a univocal evaluation).	This quality was checked at the moment of the construction by discussions within the working group.

Table 1. Indicators quality and way of testing

For the evaluation of the quality of the whole set of indicators, three aspects were considered. In multicriteria support system and especially in partial aggregation method involving numerous features, the set of indicators used is supposed to form a consistent family, meeting conditions of exhaustiveness, cohesiveness and non-redundancy (Vincke, 1992).

This has been verified in a very empirical way. Cohesiveness was checked by simple analyses. Qualitative correlations between indicators were explored to detect potential redundancy. For exhaustiveness, a first list of performance indicators were built and submitted to each member of the working group. When an aspect was missing, a performance to be dealt with was added and so on until stabilization of the list. This process does not insure the exhaustiveness of the set, the set being as exhaustive as the members' preoccupations.

2.3 Choice and principle of the multicriteria method

After defining the set of indicators, a method had to be determined in order to sort the systems that work correctly over time and those that do not perform well. To assign an existing system to one of the two categories ("performs correctly" or "does not perform correctly", the ELECTRE TRI method developed by (Yu, 1992) was chosen for three main reasons.

First, it is a multicriteria method based on partial aggregation where each criterion is expressed in its own value system and scale. As we will see further on, a large number of different types of indicators were necessary to evaluate the performance of a system. The second reason is that the method allows the user to account for uncertainties in the evaluation of the indicators. Thirdly, ELECTRE TRI fits to our decision problem. It is a method aiming at assigning actions or strategies (in our case one infiltration system) to predefined ordered categories (in our case: 2 categories "performs correctly" and "does not perform correctly") using a set of criteria or indicators.

The principle of the method is simple. First each criterion or indicator has to be weighted according to its relative importance. Secondly, the limit between 2 categories is formalized by a reference profile (in our case: just one profile (let us call it "b_1") discriminating good and bad performances). This reference profile is in fact a fictitious user-defined alternative providing references values on each criterion.

The assignment of an infiltration system (let us call it "*a*") to a category results from the comparison of *a* and the reference profile b_1 defining the limits between categories.

For the comparison, ELECTRE TRI validates or invalidates the statement ($a\ S\ b_1$) which means "*a* is at least as good as the profile b_1". For that purpose, three thresholds per criterion are defined (pseudo-criteria – Roy, 1996). The first one is the indifference threshold under which the decision maker shows clear indifference (uncertainties of indicator evaluation can be used to fix this threshold). The second is the preference threshold above which the decision maker is certain of a strict preference. In between, there will be situations of weak preference indicating decision maker's hesitation between indifference and strict preference. At last, the veto threshold (which is not compulsory) is the maximal difference which turns out to be unacceptable between *a* and b_1 on a given criterion regardless the performances on other indicators.

The validation of the assertion ($a\ S\ b_1$) is made according to two conditions: i) a concordance condition: the system *a* is at least as good as the profile b_1 if a sufficient number of criteria (indicators) are in favour of the statement; ii) a non-discordance condition: when the concordance condition holds, none of the criteria should oppose to the statement in a too strong way. Then an index, called the degree of credibility of the statement $a\ S\ b_1$ ($\sigma(a, b_1)$) calculated by using an overall concordance index and discordance indices, is built and compared with a "cutting level" (λ) in order to determine the global preference situation between *a* and b_1.

Situation 1: If $\sigma(a, b_1) \geq \lambda$, $\sigma(a, b_1) \geq \lambda \Rightarrow (aSb_1, b_1Sa) \Rightarrow$ *a* and b_1 are indifferent

Situation 2: If $\sigma(a, b_1) \geq \lambda$, $\sigma(a, b_1) < \lambda \Rightarrow (aSb_1, \text{not } b_1Sa) \Rightarrow$ *a* is preferred to b_1

Situation 3: If $\sigma(a, b_1) < \lambda$, $\sigma(a, b_1) \geq \lambda \Rightarrow (\text{not } aSb_1,\ b_1Sa) \Rightarrow$ b_1 is preferred to *a*

Situation 4: If $\sigma(a, b_1) < \lambda$, $\sigma(a, b_1) < \lambda \Rightarrow (\text{not } aSb_1, \text{not } b_1Sa) \Rightarrow$ *a* and b_1 are incomparable

Finally, two complementary procedures (optimistic and pessimistic procedures) are applied to assign each candidate to one category. In the optimistic procedure *a* is compared to b_1, if b_1 is preferred to *a*, *a* is assigned to the category "does not perform correctly". In the pessimistic procedure *a* is compared to b_1, if *a* is preferred to b_1, *a* is assigned to the category "performs correctly". The results of these two assignment procedures will differ when *a* is incomparable with b_1. In case of incomparability, the optimistic procedure would lead to assign *a* to the category "performs correctly" whereas the pessimistic procedure would assign *a* to the category "does not perform correctly".

The reader will find more details in Yu (1992) or Rogers *et al.* (2000). A sensitivity analysis of the different parameters must be done to test their influence on the final assignment.

3 PERFORMANCE INDICATORS

3.1 Flood protection

The evaluation of the criteria "flood protection" is done by two indicators: flooding frequency and global hydraulic performance.

3.1.1 Flooding frequency indicator

$IS_{HYD1} = \frac{RP_{flood}}{RP_{design}}$ (Dimensionless, preference: the lower the better, range: $[0, +\infty[$)

On a determined period, RP_{flood} is the observed return period of flood (in years) caused by events whose recurrence interval is lower than the recurrence interval used for sizing (RP_{design}).

The determined period of time has to be specifically defined for each situation (e.g. from the implementation of the system to now, from the last renovation to now, …).

3.1.2 Global hydraulic performance measuring the potential for clogging

For extensive systems, like infiltration basins

$IS_{HYD2} = \max_i (R_i)$ (in *h*, preference: the lower the better, range: $]0,+\infty[$)

R_i : global hydraulic resistance of a sub-system *i* composing the whole infiltration system according to

Bouwer's model (Bouwer, 2002) and adapted in Le Coustumer and Barraud (2007).

An infiltration system whose hydraulic resistance is higher than 24 hours is supposed to work incorrectly (Gautier *et al*., 1999 and Dechesne *et al*., 2004).

For source control systems, like pits, trenches or swales

$IS_{HYD2} = \underset{i}{Max}\,(Ks_i)$ (in m/s, preference: the higher the better, range: $]0,+\infty[$)

Ks_i : measured hydraulic conductivity of a sub-system *i*

According to the literature a system with an hydraulic conductivity (measured at different points) lower than 10^{-6} m/s is supposed to work incorrectly (Azzout *et al*., 1994; CIRIA, 1996; Ellis, 2000).

For mixed areas having extensive and source control systems

$IS_{HYD2} = \underset{i}{Max}\,(Ind_i)$ (Dimensionless, preference: the higher the better, range: $\{0, 1\}$)

Ind_i : Partial indicator specifying if clogging of a sub-system *i* is attested

If clogging is not attested Ind_i =1, else Ind_i =0. For extensive systems clogging will be attested if the hydraulic resistance is higher than 24 hours. For the source control systems clogging is attested if the hydraulic conductivity is lower than 10^{-6}m/s.

3.2 Low degradation of groundwater quality

For extensive systems, this indicator has been built according to the work conducted by F. Malard in Perrodin *et al*. (2005) and lies in the following assumptions.

Runoff water presents generally low specific conductance (< 100 µS/cm) and is saturated in dissolved oxygen. Despite of regional physical-chemical variation, the groundwater has usually higher level of specific conductance than runoff water and is under saturated in dissolved oxygen. When raining, infiltrated water normally induces a decrease in specific conductance and an increase in oxygen concentration of groundwater. If these "normal conditions" are not observed a potential dysfunction may occur and further investigations have to be done. The indicator must just specify whether the system works normally or not. For that purpose, monitoring of dissolved oxygen concentration and specific conductance has to be carried out periodically in groundwater downstream the system during rain events. The indicator is then defined as follows.

If the system works as expected (i.e. in "normal conditions" as defined before) during rain periods $IS_{GRW} = 0$ else $IS_{GRW} = 1$ (Dimensionless, preference: the higher the better, range: $\{0, 1\}$).

For example in Figure 1: during the period, most of the events induces an increase in the specific conductance and a decrease in dissolved oxygen, the basin does not work normally, $IS_{GRW} = 1$.

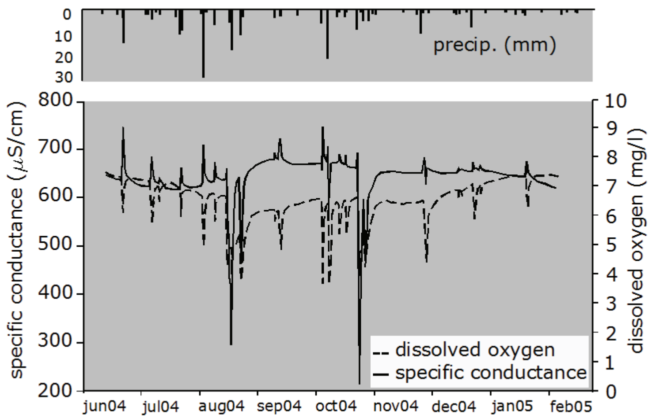

Figure 1 – Time series of specific conductance and dissolved oxygen concentration (1h time step) in groundwater under ZAC du Chêne infiltration basin – F. Malard in Perrodin *et al.* (2005)

3.3 Low soil pollution but high efficiency in terms of pollution retention

This performance is based on two indicators: pre-treatment efficiency (with regard to TSS trapped) and soil contamination.

3.3.1 Indicator of pre-treatment efficiency

$IS_{PTE} = \frac{Mp^{TSS}}{Map^{TSS}}$ (Dimensionless, Preference: the higher the better, range: *[0, 1]*)

Mp^{TSS} : Mass of TSS trapped by the pre-treatment system in a fixed period; Map^{TSS} : mass of TSS brought to the pre-treatment system in a fixed period.

3.3.2 Soil contamination indicator

After numerous definitions (Moura *et al.*, 2007b) the indicator was determined by 2 sub-indicators indicators: IS_{SOIL1} : depth where pollution becomes low or nil. (in m, preference: the lower the better, range: $[0,+\infty[$)

IS_{SOIL2} : percentage of highly polluted points (in %, preference: the lower the better, range: *[0, 100]*).

To judge if the pollution is high or low a K_1 index is used: $K_1 = \frac{\# case\ [Cmes_k \leq Cinit_k]}{\#_{totpol}}$

$\#_{totpol}$: Total number of pollutants considered; $Cmes_k$: maximum concentration of the pollutant *k* (mg/kg) measured; $Cinit_k$: initial pollutant concentration in the soil for pollutant *k* (before construction of the system) (mg/kg); $\# case\ [Cmes_k \leq Cinit_k]$: number of pollutants for which the maximum measured concentration is lower than the initial concentration or in the same range.

A low pollution is characterized by K_1 close to 1 ($K_1 \in [1-\alpha\ , 1]$, α being an exigency threshold) whereas K_1 close to 0 indicates a high level of pollution.

3.4 Aptitude to be well and easily maintained

This indicator aims to identify the facility or difficulty of the maintenance of the system and considers whether the system is well maintained or not. For different kinds of systems (basin, trench, swale, …), two check-lists were built: one for the practical aspects to be verified and one for the major dysfunctions encountered during their life span due to lack of maintenance. The complete check-lists can be found in (Moura, 2008). Two indicators are then defined.

The first one indicates if the system is regularly and properly maintained by the service in charge of operation.

$IE_{MAINT} = \#_{total} - \#_{UNDN}$ (Dimensionless, preference: the lower the better, range: $[0,\ \#_{total}]$)

$\#_{total}$: Number of maintenance tasks to be done in the system; $\#_{UNDN}$: Number of maintenance tasks undone in the system

The evaluator uses the check-list for each kind of system to number the tasks.

The second indicator is based on the dysfunctions observed *in situ.*
$IS_{MAIN} = \#_{dys_i}$ (Dimensionless, preference: the lower the better, range: $[0,\ \#_{dystotal}]$)

$\#_{dysi}$: Number of malfunctions observed in the system *i*, $\#_{dystotal}$: Total number of dysfunctions on such system according to the pre-defined check-list.

Protection of users and workers health and safety

This performance is evaluated by three indicators corresponding to different exposures and potential risks: i) one concerning risk due to soil contamination for workers or users of infiltration systems ii) one for air pollution for users and local residents, and iii) one for air contamination for workers in charge of operation.

3.4.1 Indicator of potential risk due to soil contamination for users or workers

The definition is given by:

$If\ K_4 \neq 0\%$ $\quad IS_{SAN1} = 0$ else $IS_{SAN1} = K_3 / 100$

with $K_4 = \%\,case\left\lfloor C_{mesS_k} \geq S_{5_k}\right\rfloor$ and $K_3 = \%\,case\left\lfloor C_{mesS_k} \leq S_{0,2_k}\right\rfloor$

(Dimensionless, preference: the higher the better, range: *[0, 1]*)

$\%\,case\left\lfloor C_{mesS_k} \geq S_{5_k}\right\rfloor$: Percentage of cases where $\left\lfloor C_{mesS_k} \geq S_{5_k}\right\rfloor$,

C_{mesS_k} : Measured concentration of pollutant *k* in the 30 first centimeters of the topsoil; when more than one sample is done, the higher concentration is considered, (mg/kg of dry matter);

$S_{0,2_k}$: Concentration threshold of the pollutant *k* for which the soil is considered as compatible with the use (mg/kg DM); S_{5_k} : concentration threshold of the pollutant *k* for which the soil is considered as non compatible with the use (mg/kg DM.).

The thresholds $S_{0,2_k}$ and S_{5_k} were calculated on the basis of French standards for the management of polluted sites and soil (MEDD, 2007).

3.4.2 Indicator of potential risk due to air pollution for users and local residents

$$IS_{SAN2} = \%\,case\left[\frac{C_{mesA_k}}{C_{limA_k}} > \alpha\right]$$ (in %, preference: the lower the better, range:*[0, 100]*)

$\%case\left\lfloor C_{mesA_k} / C_{limA_k} > \alpha\right\rfloor$: Percentage of cases when $\left\lfloor C_{mesA_k} / C_{limA_k} > \alpha\right\rfloor$,

C_{mesA_k} : Measured air concentration of the pollutant *k* ($\mu g/m^3$); C_{limA_k} : limit air concentration value of the pollutant *k* according to WHO (WHO, 2006), ($\mu g/m^3$); α : ratio of the real exposure duration in hours to the eight hours used to determine the limit concentration value.

3.4.3 Indicator of potential risk due to pollution of air and soil particles (for workers)

Concerning the staff we consider the air and soil exposure jointly. The indicator uses the exposure thresholds from the INRS which is the French institute competent in the area of health and safety at work (INRS, 2005).

$$\text{If } \left[\frac{C_{mesT_k}}{C_{limT_k}} > 1\right] \Rightarrow IS_{SAN3} = 100 \text{ else } IS_{SAN3} = \%\,case\left[\frac{C_{mesT_k}}{C_{limT_k}} > \beta\right]$$

(%, preference: the lower the better, range: *[0,100]*)

$\%\,case\left\lfloor C_{mesT_k} / C_{limT_k} > \beta\right\rfloor$: Percentage of cases when $\left\lfloor C_{mesT_k} / C_{limT_k} > \beta\right\rfloor$,

C_{mesT_k} : Measured concentration of the pollutant *k*, in the air and particles of soil (mg/m^3); C_{limT_k} : Threshold of concentration of the pollutant *k* according to French INRS standards, (mg/m^3);

β : Ratio of the real exposure duration in hours to the eight hours used to determine the limit concentration value.

3.5 Waste production

The indicator considers the part of the sediments cleaned out from the systems that can be reused.

$$IS_{WP} = \frac{Ms_{reus}}{Ms_{extr}}$$ (Dimensionless, preference: the higher the better, range: *[0, 1]*)

Ms_{reus} : Sediment mass which can be reused, on a defined period; Ms_{extr} : Sediment mass cleaned out of the system on the same period.

3.6 Low maintenance costs

The indicator measuring the performance "low maintenance costs" is based on the variation in the maintenance costs over time. An abnormal increase or decrease in cost must draw managers' attention.

$IS_{COST} = C_{MAc} - \overline{C_{M\,Pr}}$ (Dimensionless, preference: the lower the better, range: $[-\infty, +\infty]$)

C_{MAc} : Maintenance cost in year *j* ; $\overline{C_{M\,Pr}}$: mean of maintenance costs in previous years

3.7 Good social acceptance

As it is very difficult to estimate this aspect, the proposed indicator only considers the existence of complaints from the local residents concerning the system since its implantation or its more recent restoration.

$IS_{SA} = 0$ if there are complaints about the system since its implantation or its more recent rehabilitation; otherwise $IS_{SA} = 1$ (Dimensionless, Preference: the higher the better, range: $\{0, 1\}$)

4 CASE STUDY

To evaluate the methodology, case studies were selected. One of them is presented. It concerns a retention-infiltration basin located in an urban industrial area, located in Lyon in the south-eastern part of France. The system is a centralized one. It is composed of two compartments (one retention basin and one infiltration basin). It drains rain water from a catchment of 185 ha with 70% imperviousness). The system is old (30 years) but it has been rehabilitated in 2002 and completely cleaned in 2004. This system is not open to the public.

4.1 Performances and parameters of the methodology

The performance indicators are given in the second column of table 2, the parameters of the method in the columns 4 to 7 of table 2 (i.e. weights, indifference and preference thresholds and the reference profile). The weights presented here are the mean of three decision makers' opinion, obtained by interviews. The indifference thresholds are based on indicator uncertainties. We can notice that no veto thresholds were used. Some indicators were not calculated because of the lack of available data, like air quality and maintenance costs. Sensitivity and robustness analysis has then been carried out to test the influence of the variation of the different parameters within a coherent decision strategy. The methodology was found robust (Moura, 2008). Figure 2 presents a graphical comparison between Django Reinhardt performances and the Reference Profile.

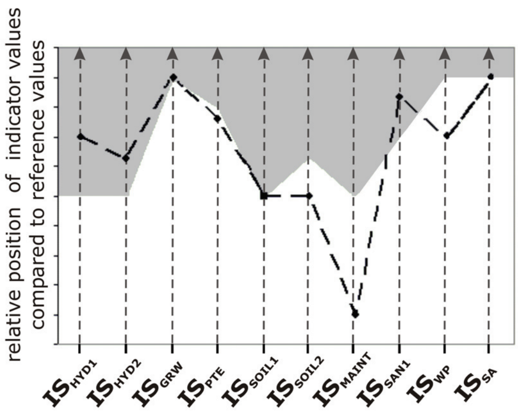

Figure 2. Django Reinhardt case study - Relative position of indicator values (dashed line) compared to the Reference values delimiting an area of good (in grey) and worse performance (in white). Each Y-axis of the different indicators are oriented from the worst to the best evaluation

Indicator	Ind. value	Data used	Weight	Indif. threshold	Pref. threshold	Ref. Profile
IS_{HYD1}	0	Observation	11.1	0	0	1
IS_{HYD2}	9 h	Hydraulic resistance calibrated according to inflow, water depth, & temperature time series	10.3	6	12	24
IS_{GRW}	1	Groundwater monitoring (dissolved oxygen concentrations & specific conductance)	14.7	0	0	1
IS_{PTE}	0.29	TSS load derived from continuous turbidity measurements	5.3	0.03	0.03	0.5
IS_{SOIL1}	1 m	Soil sampling at different depths and chemical analysis	5.3	0.2	0.5	1
IS_{SOIL2}	100 %		4.1	0	0	0.33
IS_{MAINT}	3	*In situ* observation	13.3	1	2	1
IS_{SAN1}	67%	Soil sampling and chemical analysis	6.4	0	0	0
IS_{SAN2}	-	-	-	-	-	-
IS_{SAN3}	-	-	-	-	-	-
IS_{WP}	0	None (No sediments were reused in the case study)	16.1	0	0	1
IS_{COST}	-	-	-	-	-	-
IS_{SA}	1	Inventory of complaints about the system from local residents	13.4	0	0	1

Table 2. Indicator value, data used for its calculation, weight, indifference, preference threshold and reference value of each indicator

4.2 Results and discussion

First, we can notice the lack of information to evaluate some performance indicators. It is the case for sanitary indicators related to air pollution. Actually, no measurement of air pollution is done on such systems so that we can't control the potential toxicity for the workers in charge of maintenance or for people living around the system. However, dust coming from the system is often observed and should be controlled at least once. More surprisingly, it is also the case of the indicator of maintenance cost. The municipality does not know how much the regular maintenance of a particular system effectively costs. The cost of maintenance is totaled up so that a global maintenance cost for wastewater services can be identified but not the cost of one system. In order to improve this aspect, the construction of a cost data base has been decided. The first conclusion that can be drawn is that, even if all the indicators can't be evaluated, the method points out the need of improvements in terms of data acquisition for the municipality.

Secondly, regarding the performance of the system Django Reinhardt, incomparability between its performance and the Reference Profile was found. The basin performance is outranked by the Reference Profile in the pessimistic procedure and outranks the Reference Profile in the optimistic procedure. It can be concluded that the basin presents performances close to the minimal thresholds. The managers of the basin have to see more precisely the origins of this assignment. We can assert that this result is correct; the basin has actually insufficient performance particularly in terms of maintenance and waste reuse.

Sensitivity and robustness analyses were carried out with variations of the indicator weights, of their thresholds, in the Reference Profile and in the cutting level. These analyses showed that the methodology presents high robustness and low sensitivity.

5 CONCLUSIONS

The present article showed the performance indicators to be used in the evaluation of infiltration systems, during its lifespan in order to quantify whether it performs correctly or not according to a wide range of criteria. The whole set of indicators presented satisfactory qualities.

Case studies were carried out; one is shown in the paper. The method turns out to be efficient and adapted to test the quality of an existing system. It points out the different aspects that have to be improved and indicates the necessary shift in the design of future systems. It also highlights the lack of information about some performance evaluations which may draw managers' attention and give tracks of improvement of their practice and organization.

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