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Study and Application of Alternative Methods to treat rainwater on the New Area Called Boukhadra III-El Bouni III (Algeria)

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ABSTRACT

The bibliographical analysis of the various models of calculation of the flows of storm water, it appears obvious that the curves Intensities-Durations-Frequencies, are the key elements in all the dimensioning of work relating to the cleansing, of this fact it is necessary to control the phenomenon of rain before the construction of the model of calculation of the peak flow or the construction of the hydrograph resulting at the exutoire of the catchment area. We were interested in the project rainfall to be used for different studies. It was necessary to process the available rainfall data, to be able to determine the rainfall parameters for the ANNABA region.

Key words : *Alternative methods, Intensities-Duration-Frequencies, Rainfall, ANNABA region.*

Introduction

Rainwater once precious and essential to life has become in today's city a potentially destructive nuisance. It is the construction of the city which is at the origin of the amplification of floods and pollution, so it is up to all of us who renew it every day to find a solution. The techniques of sewerage and evacuation far from the cities, imposed in the 19th century by the hygienists, have proved their limits today to fully control the phenomena of flooding and pollution on the whole of our agglomeration.

In this field, individual actions on the scale of each parcel can bring a real complement to collective solutions. Let's give rainwater its rightful place in our gardens and together we will build a more pleasant agglomeration that respects the water cycle.

Water management in urban areas has three objectives Limit the risk of flooding Limit the risk of pollution Integrate stormwater management into development.

The network is saturated, developed more than a century ago in the urban center, the sewerage system cannot accept all the rainwater. When flows are too great, during violent storms, the sewers become overloaded and end up overflowing onto the road, flooding roads and homes. Do wastewater treatment plants provide a solution? No, they were designed to treat effluents loaded with organic matter produced by humans (domestic water from toilets, sinks, washing machines...), not to evacuate rainwater! Moreover, they are not designed to receive large quantities of water and are more difficult to treat heavy metals and other important wastes.

The most efficient approach to treat rainwater is the Alternative Technique through :

- Filtration through soil and vegetation: the passage of water through vegetation and soil is slowed down: the pollutants fixed in the water have time to settle in the soil and the bacteria that live there play their full purifying role.

- Decantation: the water that overflows can be considered as more than 80% purified, after decantation.

Materials and Methods

Presentation of the study area

The study area is located at the level of the future city of el BOUNI. Former agricultural land, today, this area is intended to play an important role in the area given its strategic position (Place of articulation between El BOUNI and BOUKHADRA). In position between two urbanizations, this site is intended to accommodate large-scale facilities.

The local climate is Mediterranean, mild and humid in summer due to the proximity of the sea, humid and cool in winter. Temperatures are above 19°C from May to October. The annual averages vary from 13 °C to 19 °C on the coast (average monthly temperature = 12.42 °C.). The rainy period extends from October to April and reaches a monthly average of 162.42 mm (annual average = 1,000 mm) (URBAN, 2013). January remains the wettest month (average 297.87 mm) and the coldest (average 7 °C). The humidity reaches 70% on average annually due to the regulating effect of the sea.(Mellouk and Aroua ,2015).

The study area is subject to a Mediterranean climate, and according to climagram of Emberger, 1977, our study area belongs to the subhumid domain (Boudjema, 2010).

El Bouni: Located about 8 km south of the city of Annaba, the town of El Bouni is located at the bottom of the foot mountain of Edough, framed by the North of Annaba and Seraidi, the South of El Hadjar, Berrahel and Sidi Ammar, the East by El Taref and by the West of Oued Aneb, it is considered the 2nd municipality of the Willaya of Annaba. El Bouni is characterized by a set of industrial activities (the phosphate complex, Asmidal, the steel complex of ISPAT ...) which are considered as major sources of pollution (Douafer, 2010)

Geographical situation

The wilaya of Annaba has been studied geologically by Blayac (1912), Joleaud (1936) and Drand-Delga (1955) and geographically by Bardinet (1973), Tomas (1977) and Cherrad (1979) (Bardinet, 1981).

The air of the study area is delimited as follows:

- To the West and North: by BOUKHADRA ;
- To the south: by the new road of wilaya 22;
- To the east: by the southern entrance to the city of ANNABA RN16;
- The land covers an area of 190 ha.

Topographical and morphological situation:

The study area is surrounded by a relatively rugged terrain, the land that is the subject of our study has a varied morphology and very uneven geological formations alluvial origin lagoon-marine and metamorphic formation, ranging from gentle slopes in the center, to steep slopes at the ends.

Climatology

The climate of the commune of EL BOUNI is identical to that of the full of ANNABA which is of Mediterranean type with two bioclimatic tendencies related to the topography, the sea and the vegetation.

In general on the heights reigns a subhumid climate and on the low parts (plain) a warm subhumid climate. It is characterized by two seasons:

- A mild and wet winter season from October to April with 86% of rainfall and an average temperature of 14.3 C°.

- A hot and dry summer season from May to September with 14% rainfall and an average temperature of 24 C°.

How to choose the appropriate alternative technique

Upstream studies

Within the framework of a construction project, the petitioner has to choose a technique, which must take into account several parameters. The nature of the project (simple or complex) and the available space: dense urban context, peri-urban; the mode of sanitation: collective or individual; the local environmental conditions and the uses linked to water downstream of the project: soil, subsoil (water table), existence of a natural outlet nearby (watercourse, water body); the nature of the project and its potential impacts on the natural environment; the geological nature of the soil; the value of the work (water is a structuring element of the urban fabric); the cost, maintenance and management of the structure to ensure its durability.

During the study, particular attention must be paid to the following elements

Topography

The study of the topography of the site is the first technical stage to be carried out in order to check the feasibility of the project:

Based on the headwater elevations of the incoming and outgoing storm drains,

By evaluating the storage capacity for different water level elevations,

By approaching the volumes of earthworks that may be required.

Geotechnical studies was presented in Table 1.

Table 1. Geotechnical studies

Data	
Planned infiltration	$K = 10^{-3}$
Runoff coefficient	Cr = 0.6
Rain intensity	I = 180 l/s, a

The geotechnical studies allow to appreciate the feasibility of realization of a work. These studies allow to define :

If the soil materials are suitable for a good stability of the slopes, especially during the realization of basins,

The permeability of the materials, their compaction methods,

The foundation of the works, the constraints of implementation...

Hydrology/Hydraulics

The hydrology allows to calculate the water input of the catchment area and the volume of water to be stored.

Hydraulics allows the dimensioning of the upstream and downstream transport network as well as the technical works of the structure. The calculations allow to specify the necessary storage volume and the behavior of the retention structure (emptying time, highest water level...).

Water quality study

It allows to identify the objectives of runoff water depollution in the retention structure.

The data obtained from these different studies is an essential prerequisite for the construction of a retention structure. They allow the definition of the best possible layout taking into account all the technical criteria.

Modeling and sizing of alternative techniques

In order to facilitate the understanding of these compensatory techniques, four models are proposed in this work, taken from the study area, taking into account all the characteristics of each parcel (surface, soil permeability, intensity, return period, leakage rate...).

Results

Mujahidin directorate

Principle

The surface of the impermeable surface layer covers a totality. It is assumed an infiltration in the sub-layers.

We applied the alternative technique by realizing wells of infiltration of 1,2 m of diameter of 2.50m of depth. Allowing to drain some thousands of square meters and to evacuate waters directly in the ground. This technique has the advantage of being able to be used in areas where the surface layer of soil is permeable but for which the deep layers have important infiltration capacities as shown in Table 2 and 5.

Table 2. Alternative technique by realizing wells of infiltration

Dimensions of the work	
Surface	A = 6631 m^2
Radius of the well	r = 0.6 m
Depth of well	p = 2.5 m

Calculation of the leakage rate sowed in Table 3 Runoff Rate Calculation showed in Table 4 and Figure 1.

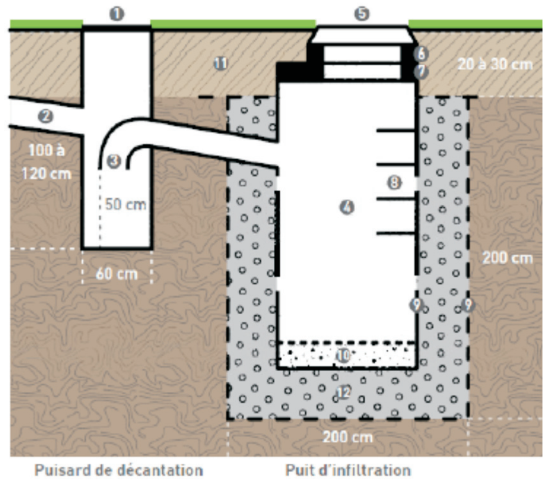

Fig. 1. Runoff rate in wells

Music school

Principle

The alternative technique of a draining trench is chosen, which has a small footprint placed on the road or the ground, with a shape similar to a parallelepiped. It is assumed that the structure is filled with a certain porosity as represented in Table 6.

Calculation of the leakage rate sowed in Table 7 Calculation of runoff rate showed in Table 8.

Table 6. Alternative technique of a draining trench

Dimensions of the work	
Total surface area	4042 m^2
Unbuilt area	A_1 = 500 m^2
Trench length	l_1 = 10 m
Trench length	L_1 = 1 m
Trench depth	t_1 = 0.5 m

School of fine arts

Principle

In the same way as for the music school, we have

Table 3. Leakage rate.

Calculation results		
Vertical surface	$S_{paroiverticals} = 2\pi \times 5r \times p$	$S_{paroiverticals} = 9.4\ m^2$
	$S_{paroiverticals} = 2\pi \times r \times p$	
Leakage rate	$Qf = 0.5 \times S_{paroiverticals} \times K$	Qf = 0.0047 m^3/s
	$Q_f = 0.5 \times 9.4 \times 10^{-3}$	Qf = 4.7 l/s

Table 4. Runoff rate calculation

Calculation results		
Runoff rate	Q = Cr × I × A	Q = 71.61 l/s
	Q = 0.6 × 180 × 10^{-4} × 6631	
Number of infiltration wells	N = Qf/Q	N= 15 wells
	N = Qf/Q	

Table 5. Alternative technique of Mujahidin Directorate

1	Visible sight glass	7	Reducing slab(H 15cm)
2	Rainwater inlet	8	Level
3	Extension elbow	9	Water permeable tarpaulin (non-woven geotextile)
4	Well element (L=100 cm)	10	Filtering layer (river sand, coarse pebbles, to be replaced periodically)
5	Lockable manhole compatible with passage (pedestrian, cars...)	11	Topsoil.
6	Raising under frame (H 15cm)	12	Coarse limestone (gravel 20/80)

Table 7. Calculation of the leakage rate.

Calculation results		
Vertical surface	$S_{paroiverticals} = 2 \times (t_1 \times l_1 \times t_1 \times L_1)$ $S_{paroiverticals} = 2 \times (0.5 \times 10 + 0.5 \times 1)$	$S_{paroiverticals} = 11\ m^2$
Leakage rate	$Q_f = 0.5 \times S_{paroiverticals} \times K$ $Q_f = 0.5 \times 11 \times 10^{-3}$	$Q_f = 0.0055\ m^3/s$ $Q_f = 5.5\ l/s$

Table 8. Calculation of runoff rate.

Calculation results		
Runoff rate	$Q = C_r \times I \times A_1$ Q = 0.6 × 180 × 10–4 × 500	Q = 5.4 l/s
Number of infiltration trenches	$N = Q_f/Q$ N = 5.5/5.4	Les dimensions sont vérifiées

Table 9. Alternative technique of a draining trench

Dimensions of the work	
Total surface area	4235 m^2
Unbuilt area	$A_2 = 560\ m^2$
Trench length	$l_2 = 8$ m
Trench length	$L_2 = 1$ m
Trench depth	$t_2 = 0.8$ m

chosen to use the alternative technique of a draining trench (Figure 2) which has a small surface area placed on the road or the ground, with a shape similar to that of a parallelepiped, assuming that the work is filled with a structure of a certain porosity represented in Table 9.

Calculation of the leakage rate showed in Table 10:

Figures 2 and 3 shows an example of drainage trench also Structural sections of drainage structure

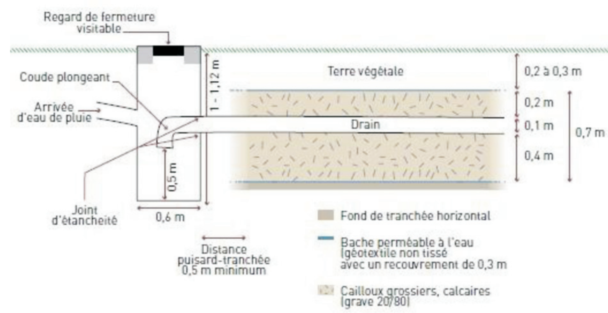

Fig. 2. Example of a drainage trench.

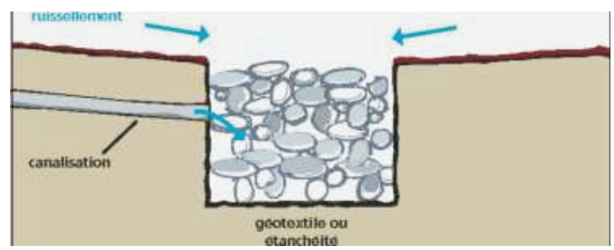

Fig. 3. Structural sections of drainage structure.

Table 10. Calculation of the leakage rate.

Calculation results		
Vertical surface	$S_{paroiverticals} = 2 \times (t_2 \times l_2 + t_2 \times L_2)$ $S_{paroiverticals} = 2 \times (0.5 \times 8 + 0.8 \times 1)$	$S_{paroiverticals} = 14.4\ m^2$
Leakage rate	$Qf = 0.5 \times S_{paroiverticals} \times K$ $Qf = 0.5 \times 14.4 \times 10^{-3}$	$Qf = 0.0072\ m^3/s$ $Qf = 7.2\ l/s$

Table 11. Calculation of runoff rate

Calculation results		
Runoff rate	$Q = Cr \times I \times A_2$ $Q = 0.6 \times 180 \times 10^{-4} \times 560$	$Q = 6.048\ l/s$
Number of infiltration trenches	$N = Q_f \backslash Q$ N = 7.2/6.04	The dimensions are checked

Parking Spaces For The Hospital

The study of the dimensions of the work including the total surface area, trech dimension are shown in Table 12.

Table 12. Alternative technique of a draining trench.

Dimensions of the work	
otal surface area	9950 m^2
Trench length	$l_3 = 99.74$ m
Trench width	$L_3 = 99.74$ m
Trench depth	$a_3 = 0.6$ m

Calculation of the leakage rate showed in Table 13.

Calculation of runoff rate showed in Table 14 and Fig. 4.

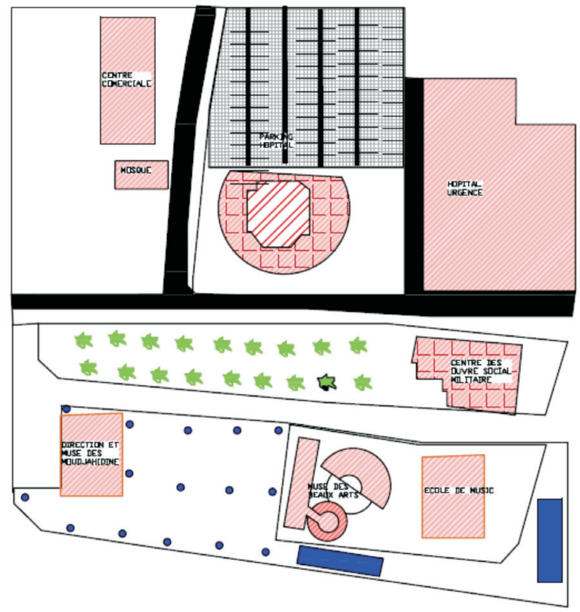

Fig. 4. Location of dimensioned structures.

Discussion

The world currently has 19 cities with more than 10 million inhabitants, and will have 27 by 2025. The consequences of this inexorable urban development are an increasing sealing of surfaces and thus an increase in urban runoff, since water infiltrates less into the soil. The water thus arrives much more quickly towards the low points, not allowing a progressive flow towards the sewerage systems. This imbalance causes multiple risks of flooding, which are becoming more and more frequent and worrying, as well as an additional transfer of pollutant flows to the natural environment and a theoretical decrease in groundwater recharge. Since the 19th century, different concepts have shaped stormwater management: a hygienic concept appeared in the 19th century in developed countries with the main objective of evacuating as quickly as possible "dirty water of any kind" from the city. In order to do so, underground sewerage networks were created and developed until the 1960s. At the end of the 1960s, the hydraulic concept of sanitation appeared and advocated the slowing down of runoff on urbanized surfaces thanks to the creation of rainwater retention basins. The term "alternative techniques" then appeared and associated, in addition to storage basins, infiltration techniques, on a more or less large scale,

At the end of the 1980's, the environmentalist concept was imposed by taking into account the impact of stormwater on the receiving environment, particularly due to the sealing of soils and the extension of urbanization, which generated more and more volumes of stormwater to collect. This situation leads to the use of larger and more expensive underground structures to evacuate rainwater. This

Table 13. Calculation of the leakage rate.

	Calculation results	
Vertical surface	$S_{paroiverticals} = 2 \times (a_3 \times l_3 + l_3 \times L_3)$ $S_{paroiverticals} = 2 \times (0.6 \times 99.74 + 0.6 \times 99.74)$	$S_{paroiverticals} = 239.37$ m^2
Leakage rate	$Qf = 0.5 \times S_{paroiverticals} \times K$ $Qf = 0.5 \times 239.37 \times 10^{-3}$	$Qf = 0.1196$ m^3/s $Qf = 119.68$ l/s

Table 14. Calculation of runoff rate

	Calculation results	
Runoff rate	$Q = Cr \times I \times A_3$ $Q = 0.6 \times 180 \times 10^{-4} \times 99.50$	$Q = 107{,}46$ l/s

concept is also taking off due to the evolution of public policies and aims, through a more "global" approach, to simultaneously ensure different issues, such as the protection of property and people, as well as the protection of the environment.

Alternative techniques are no longer presented only as technical sanitation tools, but also as urban, multifunctional and integrated facilities in the city. The restoration of a local water cycle in the urban environment thus becomes a challenge to be met within the framework of "sustainable" development projects and a real opportunity to improve the integration of water in the city and to consider water as a resource and no longer as a constraint or a nuisance.

In recent years, the issues of improving the living environment, reappropriation of water by the inhabitants and adaptation to climate change have become significant, with the observation of a decrease in rainfall, an increase in episodes of heavy rainfall, but also in temperatures and deterioration of air quality. The metropolitan scale of the Eco-City thus appears as a real opportunity to respond to these issues, in order to allow : a better hydraulic regulation of water;a treatment of water before discharge into the natural environment the development of a new biodiversity water;the improvement of the living environment in connection with water management, by developing spaces for exchange and sharing for the inhabitants; the fight against the phenomenon of heat islands, potentially coupled with other innovative measures such as the development of shaded and vegetated areas, the choice of materials with low heat absorption; saving water by using raw water (non-drinking) for example; and more broadly, a contribution to the well-being of users in the city.

Conclusion

It is necessary to manage the rainfaull phenomone while he Intensity-Duration-Frequency curves are the key elements in all the design also this studies is focusing on the rainfaull parameters for Annaba region.

Acknowledgement

We would like to thank (ABH Agence de Basin Hydrographique Constantinois-Seybouss mellegue 'antenne de Annaba') for providing all necessary informations.

Data availability

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request

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