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ORIGINAL ARTICLE

New software to analyze hydraulic incidents in Algeria

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Abstract
Fifteen percent of the total volume produced is lost, which has become a major problem for water resource management in Algeria. The number of high leakages reduces the performance of the drinking water supply network. The disturbance of the drinking water supply observed by the citizens resulted from several incidents occurring mainly on the axis of production or distribution (e.g., breakage, leakage, pollution, electrical problems, and drought). To manage these incidents and for water distribution monitoring in the high-level strategic plan, monitoring and control software was developed for the Algerian Water Company (ADE). This software is an essential tool that helps managers of water resources to monitor the water supply situation throughout the national territory to ameliorate water public services. This dynamic software has been in use since 2016.

Keywords Algeria · Algerian water company (ADE) · Leakage · Incidents · Software · Water distribution monitoring

Introduction

Water stress is a major problem in the world (Rochdane et al. (2012); Hamlat et al. (2013); Ali Rahmani and Chibane (2017; Li et al. 2018) industrialization, urbanization, and rapid population growth have placed huge stress on water resources (Daud et al. (2017)). Water resource management has become a fundamental action in the Algerian development policy (Loucif (2003); Medejerab and Henia (2011); Bouklia Hassane et al. (2016)). Many issues arise in operational fields that disrupt the continuity of water supply, particularly in areas with poor supply networks and insufficient water resources.

At the daily scale, many disturbances are observed in all Algerian cities, especially in the periods of summer and winter because of climate disturbances and electric power interruptions in the pick time, which damage hydraulic facilities and interrupt the continuity of water distribution services (Galway 2016; Kumpel et al. 2016).

Several regions in Algeria suffer from the lack of water resources and present severe difficulties to supplying people with drinking water. The main factors of these difficulties are as follows:

- Irregular rainfall and drought
- Overexploitation of the water table (drawdown).
- Loss of water produced in intake and distribution pipes
- Lack of water storage facilities.
- Older distribution networks and classical design.
- Poor water quality and (high turbidity and salinity).
- Rapid demographic growth up

All these technical problems were taken seriously by the Authority in Algeria. The water public services in Algeria have great importance in the Algerian national policy.

History of development of software

In the Algerian territory, the record of incidents occurring in hydraulic facilities was done manually with paper registers, which makes it difficult to process and analyze incidents either at the spatial scale, or at the temporal scale. To improve incident management, we have developed hydraulic data processing software that is free of charge for the Algerian National Water Company (ADE). This software has been in use since 2016 at the general headquarters of the Algerian water company.

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Table 1 Main hydraulic facilities of the Algerian water company (2020)

Identification	Unit	Number	Capacity m^3/day
Boreholes	U	3 833	3 880 570
Sources	U	351	250 607
Wells	U	232	68 065
Pumping stations	U	1 792	11 557 071
Treatment plants	U	91	2 783 958
Distribution Tanks	U	7 543	6 417 785 m^3
Adduction Networks pipe	Km	29 863	–
Distribution Networks pipe	Km	53 543	–
Total linear pipe	Km	83 407	–

Materials and methods

Presentation of the algerian water company

The Algerian water company (ADE) was created in 2001 by the Algerian government to transform the management of water supply from municipalities. ADE is the greatest water production and supply company in Algeria, covering more than 84% of Algerian citizens in terms of drinking water. The total population served is 36 million inhabitants.

As shown in Table 1, the Algerian water company had a large number of hydraulic facilities by 2020.

Figure 1 shows the location of the General headquarters of the Algerian water company.

Development method

The development of this work is based on the processing of valuable information about the situation of water supply in the Algerian localities. The user interface is developed by the Delphi environment; it is a high level imperative programming language. It was designed as a language in general use in the 1960s (Langfield 2003). Delphi is a visual programming tool that contains an integrated development environment (IDE), which allows the development of programs and software with graphical user interfaces (GUIs).

The principle of this work is to develop software with a local database that can save, treat and analyze data about hydraulic incidents. This software is a decision support system for the authority in Algeria.

The information treated can be filtered by name of province, by date or id of incident. The fast report option allows printing all types of information and a prepared model of reports that contain information about the incident. The software has four export formats of reports (PDF, HTML, word and CSV). The software was developed in the Algerian water company to exploit and manage daily information about the state of water supply program across the Algerian territory.

User interfaces

The user access window (Fig. 2) is a secure tool to use the software Fig. 3. It is necessary to write user identification (name and password) to obtain access to the working interface to protect data and for workflow traceability Fig. 4.

The working environment window will appear after the login procedure. The user interfaces have basic control pages that contain the most useful functions as follows:

- The principle database that contains list of incidents in the croissant order.
- Details of incidents (nature, date, cause, impact on population and type of incidents).

Figure. 1 Headquarters of the Algerian water company (APS, 2020)

Figure. 2 Administration login windows

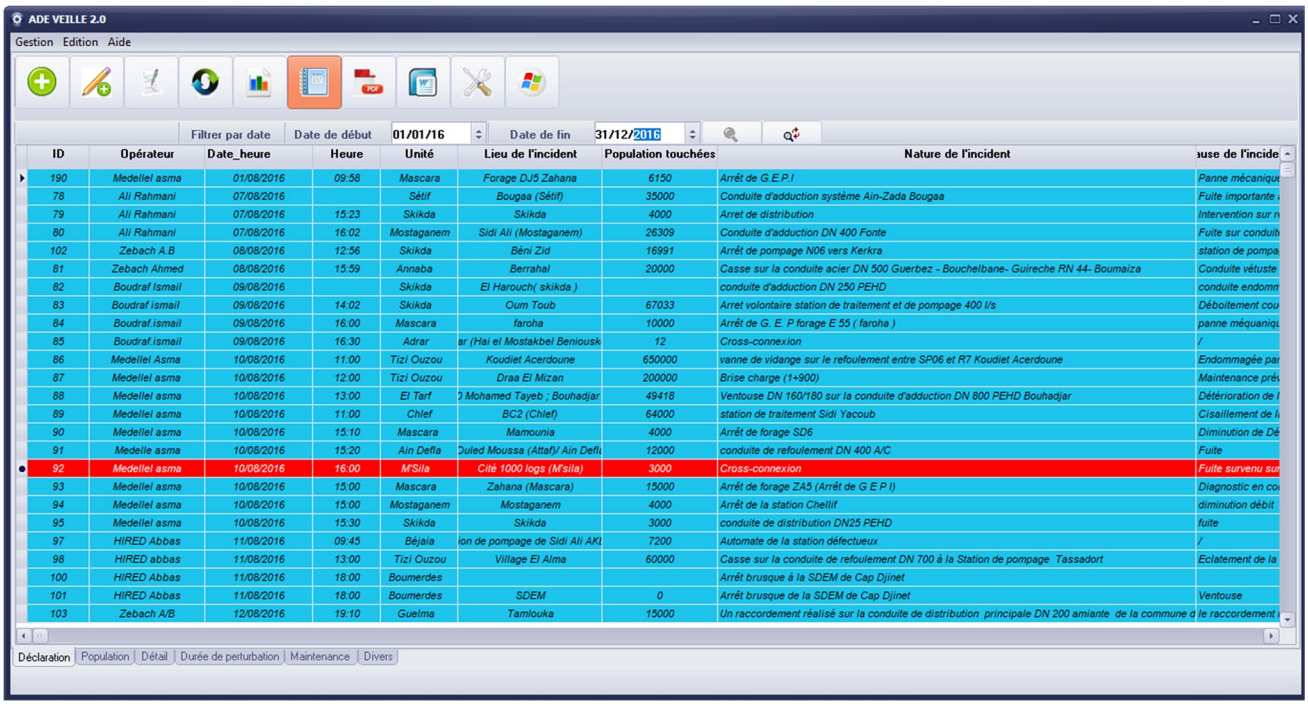

Figure. 3 User interface

- Timescale showing the duration of water supply perturbation before restoration.

According to our experience in the field, we have identified many kinds of hydraulic incidents that occur in the water supply systems Fig. 5. The natures of these incidents are illustrated in Table 2 and are divided into four groups Fig. 6.

Case study

The analysis of data for 2016/ 2020 allowed us to extract very important information about the situations of water resources supply in Algeria, and the main type and classes of these problems. This kind of information allows the Algerian authority a global idea about the water crisis in the region Fig. 7.

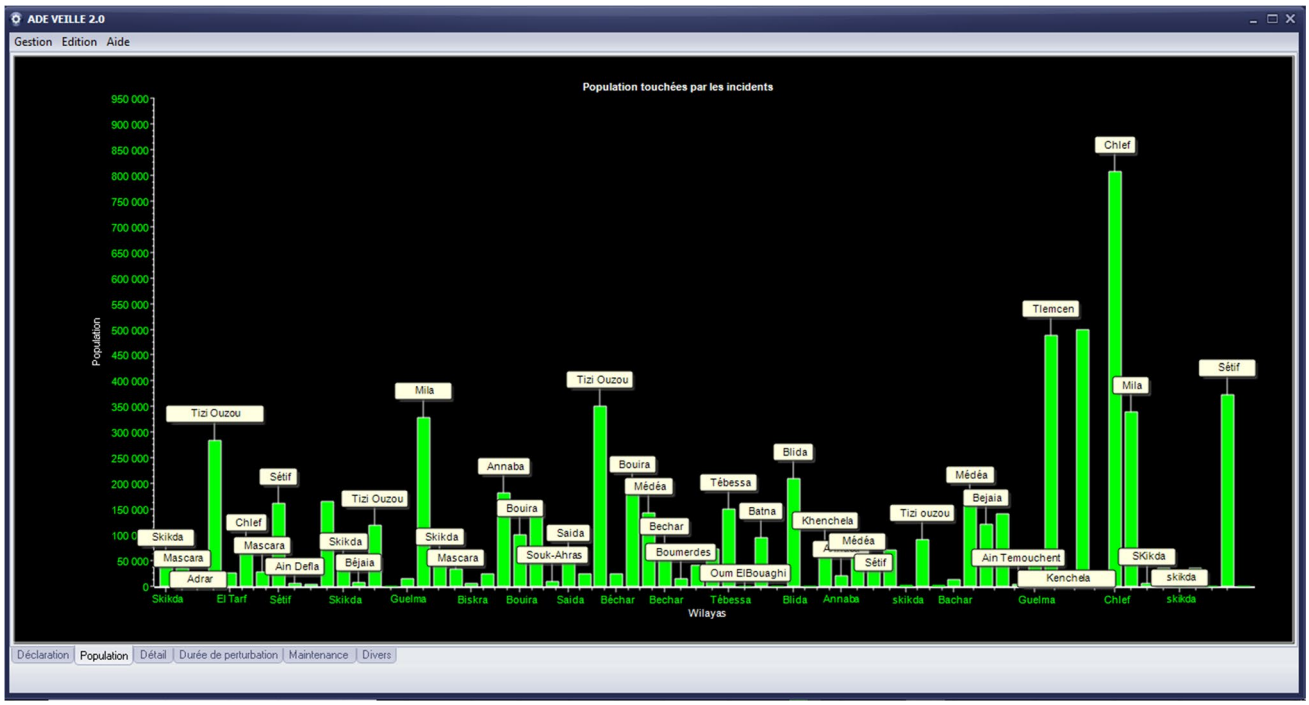

Figure. 4 Graph showing the impact of water distribution incidents on population

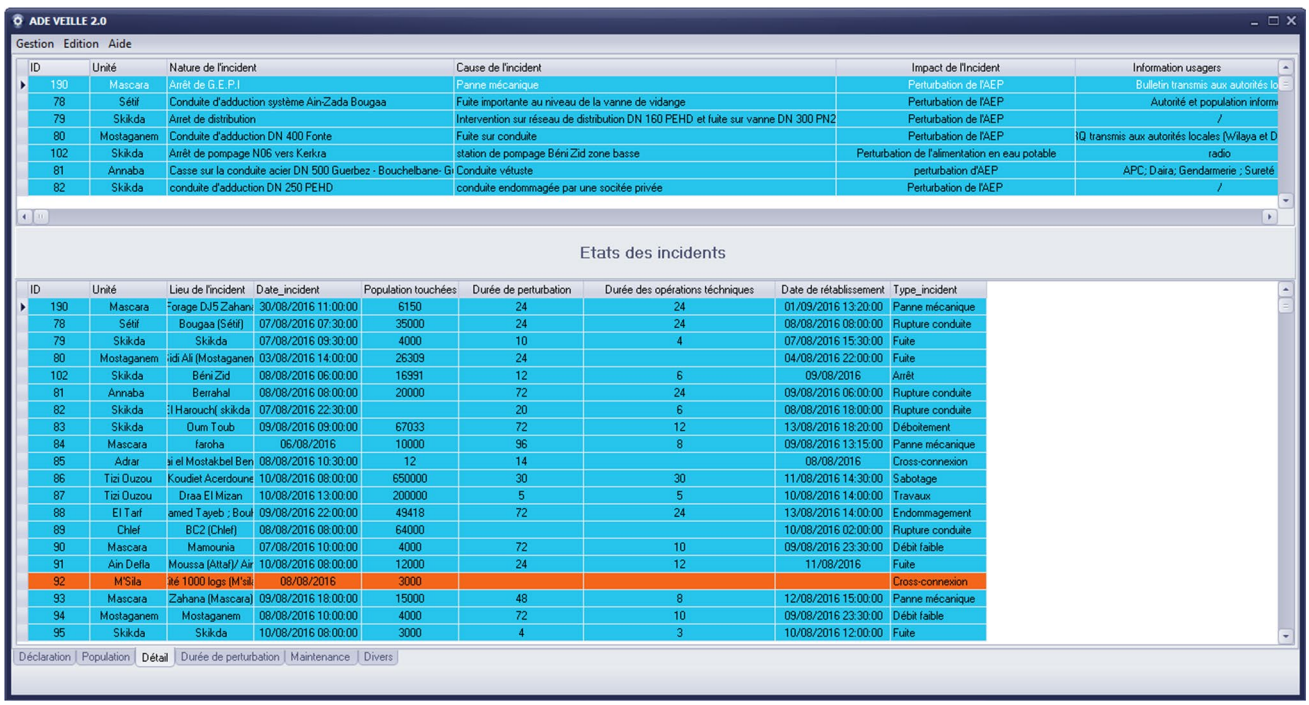

Figure. 5 Detailed windows which all information can be extracted

Table 2 Topology of incidents

Group	ID	Incidents type
1- Adductions networks	1–1	Act of vandalism
	1–2	Leakage on pipe
	1–3	Failure on hydromechanical equipment (valve, suction cup)
	1–4	Other adduction and transfer incidents
2- Water production structures: (Boreholes, b. Pumping station, Treatment station)	2–5	GEPI mechanical failure
	2–6	GEPI electrical failure
	2–7	Leak on riser
	2–8	Power failure (Control cabinet)
	2–9	Drawdown
	2–10	Pollution (Infiltration of wastewater, hydrocarbons, Nitrate, Ammonium, heavy metals, marine intrusion)
	2–11	Sand rising
	2–12	Casing tear
	2–13	Clogging of the strainer
	2–14	GEPI fall
	2–15	Landslide
	2–16	GEPH mechanical failure
	2–17	GEPH electrical failure
	2–18	Poor raw water quality
	2–19	High turbidity
	2–20	Electrical power cuts
	2–21	Scheduled shutdown (For work)
	2–22	Act of vandalism
	2–23	Other
Storage structures	3–24	Advanced degradation of the structure
	3–25	Breaking of the work
	3–26	Leak on the pass-wall
	3–27	Collapse of the dome
	3–28	Wall cracking Leak (valve chamber)
	3–29	Other
Distribution networks	4–30	Act of vandalism
	4–31	Connection leak
	4–32	Leakage on pipe
	4–33	Leaks on hydromechanical equipment (valve, suction cup)
	4–34	Cross-connection
	4–35	Other

Figure 8 shows the frequencies of each type of water supply incidents given by the software. The frequency of each type are given in Table 3

Figure 9 shows the number of incidents per province in Algeria, for the reference year.

Figure 10 shows the perturbation duration of water supply interruption caused by hydraulic incidents. This parameter is given in hours and is calculated based on the time of incident and the necessary time needed to repair the incident.

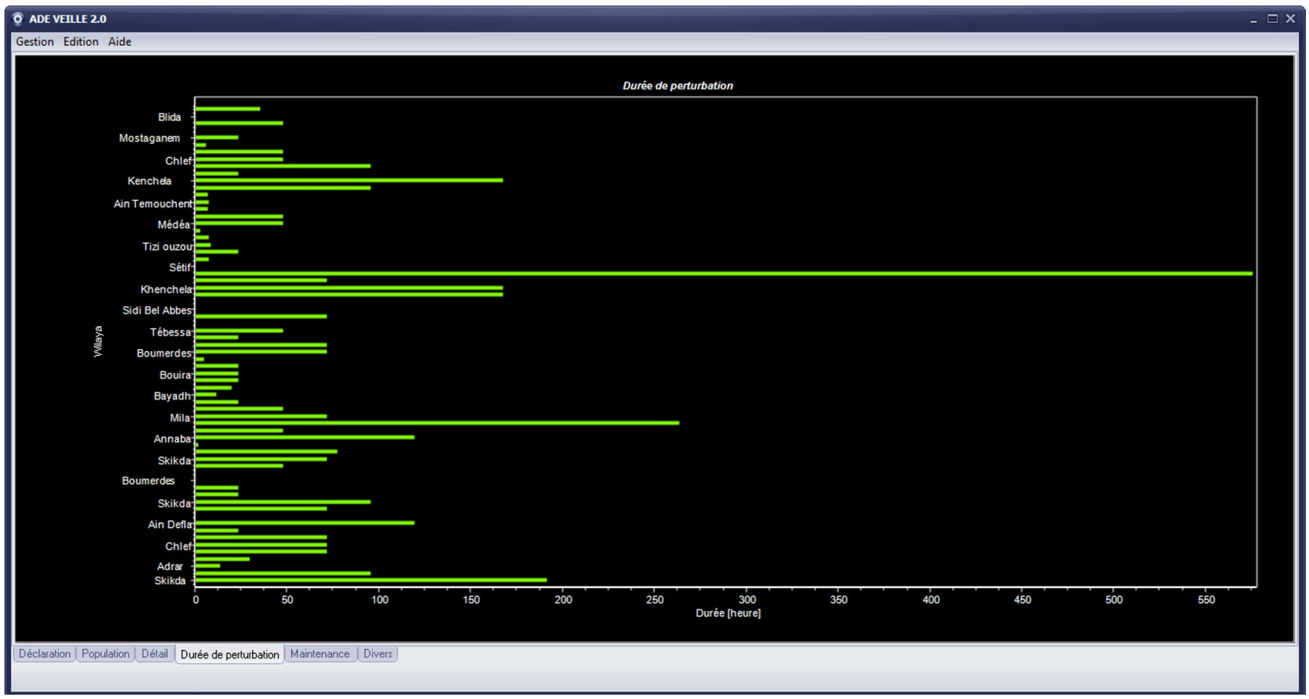

Figure. 6 Graph showing the duration and time of water supply perturbation given in hours

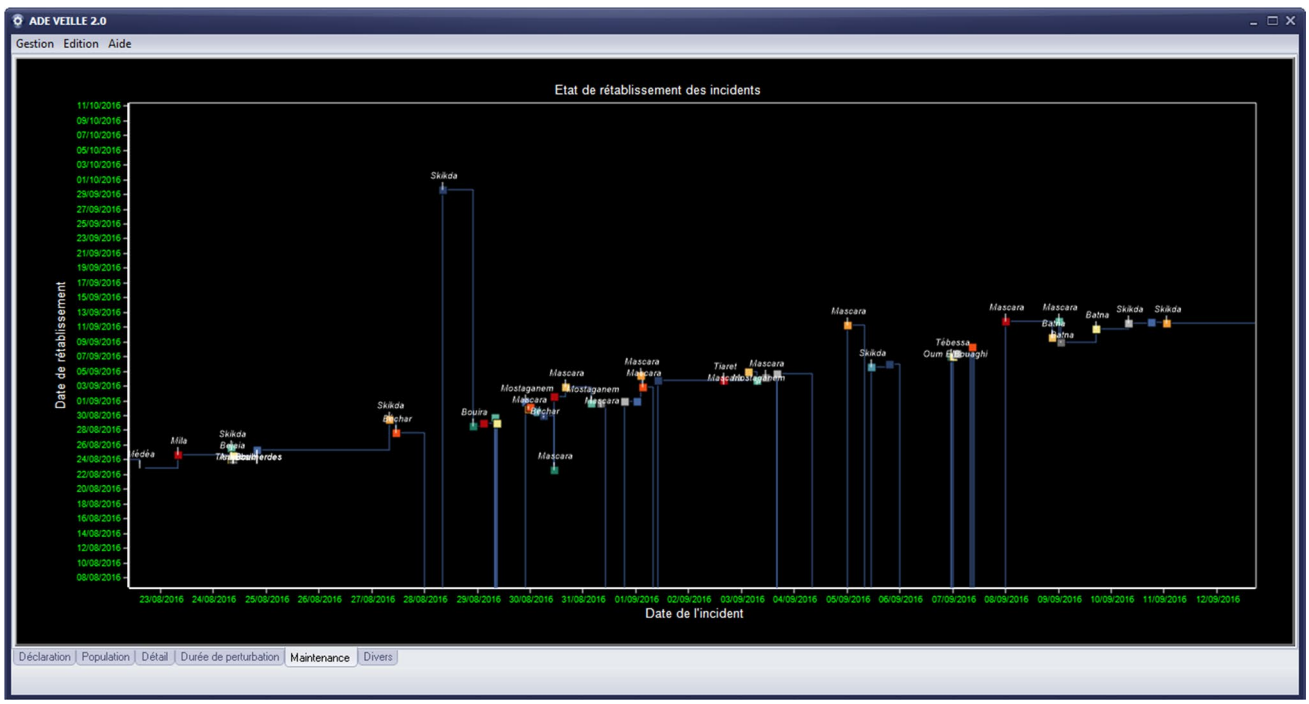

Figure. 7 State of maintenance of hydraulic incidents

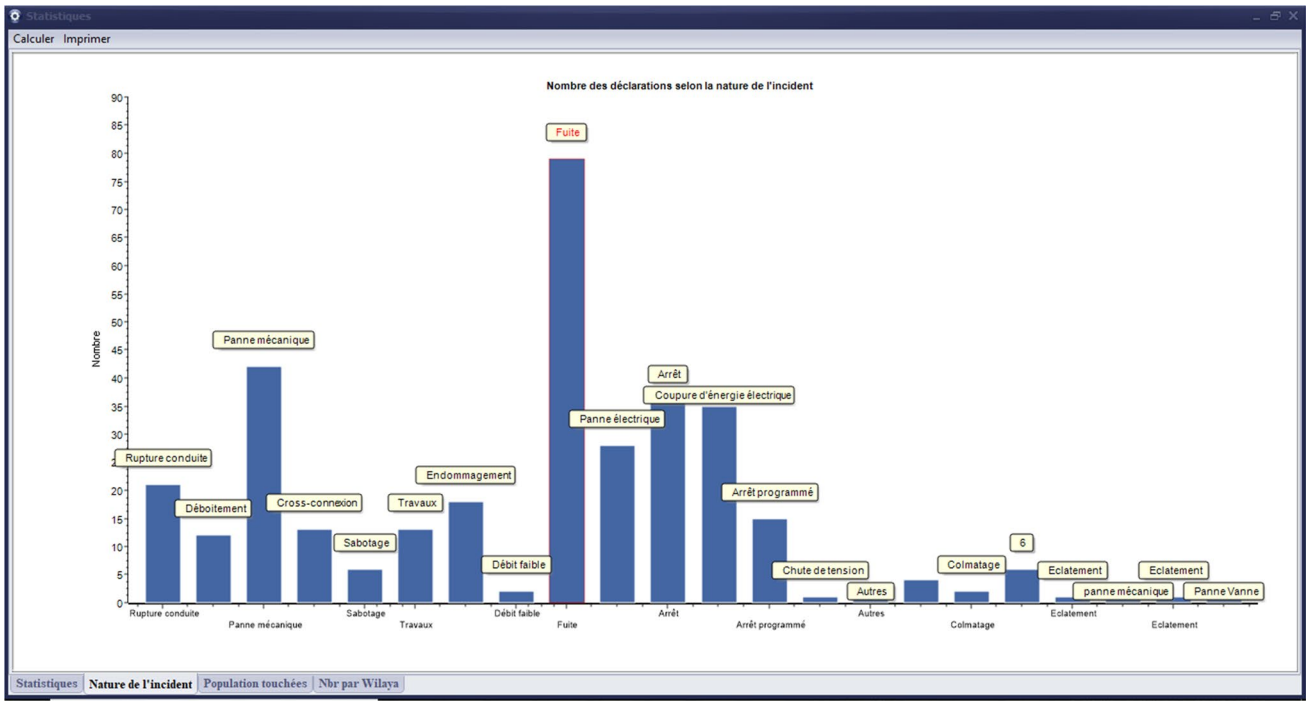

Figure. 8 Frequencies graphic type of each type of incident

Figure 11 shows the report generation window. The user can export a predesigned report that contains all hydraulic incidents that happen on a specified date; this report is transmitted to the Ministry of Water Resources every day.

The main incidents that occurred in the national territory and disturbed the continuity of the water supply were leakage, failure of pumping stations due to electrical, mechanical and sometimes electronic dysfunction, electrical shutdown and emerged pumping failure (Table 3).

Figure 12 shows the frequency of hydraulic incidents.

Conclusion

SUREAP is integrated software developed for the management of the most common occurred problems in the water resource supply facilities. The software collects all available data in a single system, which facilitates the identification of errors and the definition of actions to improve performance. Standard dashboards provide qualitative and quantitative data to help the user troubleshoot calculations, take action to reduce non-compliance, mitigate risk, and predict performance. Check the overshoot by comparing the results to the authorized limits. This software is now operational in the crisis cell of the Algerian Water Company Since 2016. It is the principle database of water supply incident history.

Table 3 Category and frequency of major hydraulic incidents recorded in the SUREAP software during the period of September 2016–December 2020

ID	Number	Frequency
Leak	2139	0.2712
Pumping station failure	1042	0.1321
Electrical power shutdown	738	0.0936
Emerged pump failure	1097	0.1391
Pipe breakage	390	0.0495
Maintenance work	534	0.0677
Electrical failure	342	0.0434
Mechanical Failure	295	0.0374
Treatment station failure	217	0.0275
Drawdown	132	0.0167
Pollution	131	0.0166
Desalination station failure	129	0.0164
Others technical failure	122	0.0155
Valve failure	115	0.0146
Discharge of the pipe	110	0.0139
Act of sabotage	72	0.0091
Poor raw water quality	72	0.0091
Electric cabinet breakdown	65	0.0082
Network clogging	61	0.0077
Electrical voltage drop	41	0.0052
Reduction in the production of the desalination plant	29	0.0037
Water tank disinfection	8	0.0010
Tip on suction cup	5	0.0006
Total	7886	1.0000

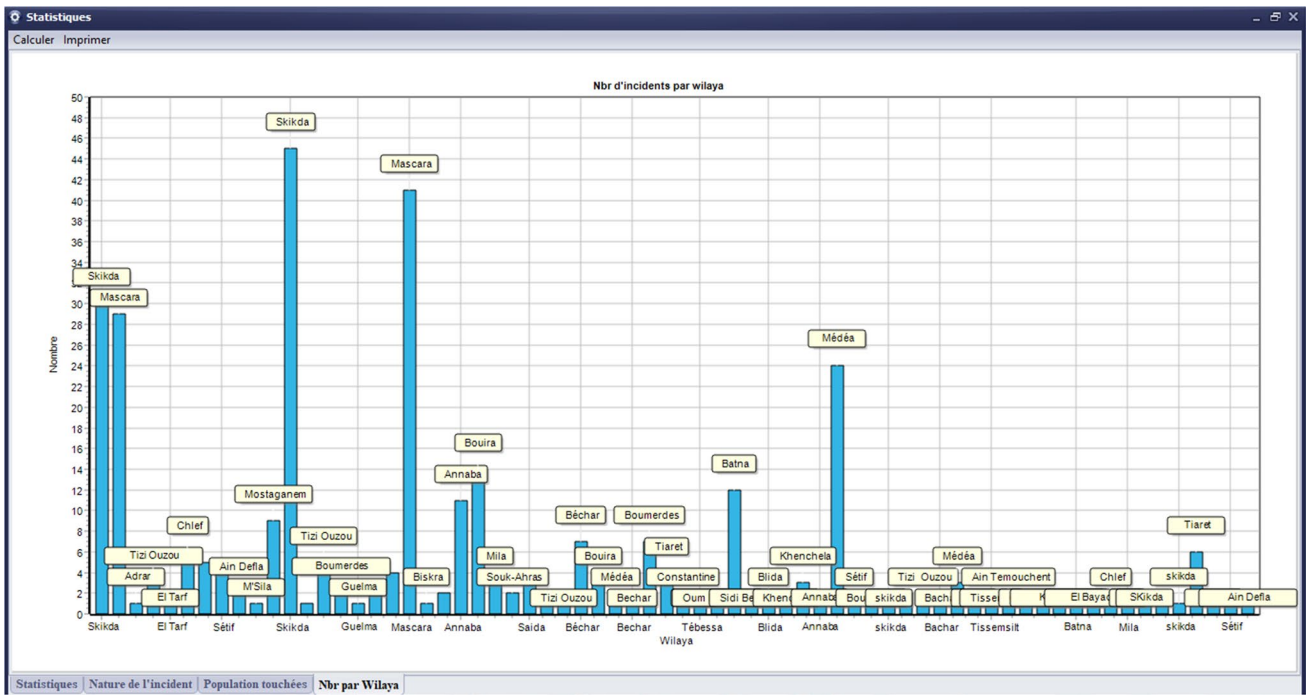

Figure. 9 Frequency of incident classified by province

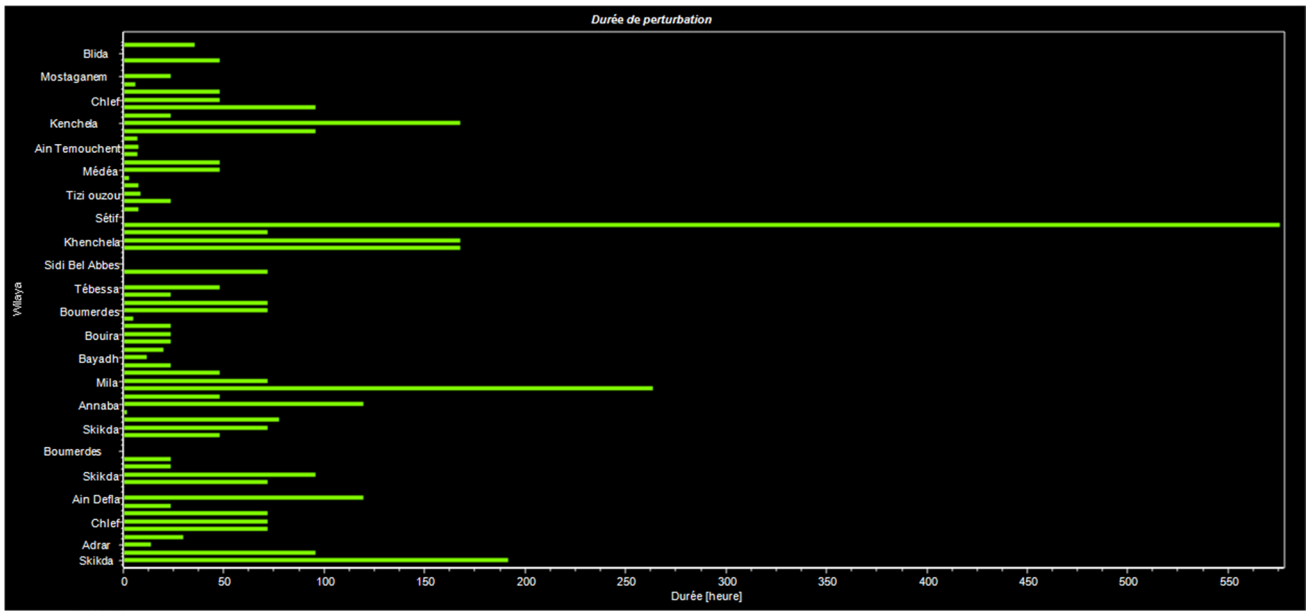

Figure. 10 The duration of water supply interruption caused by the incident

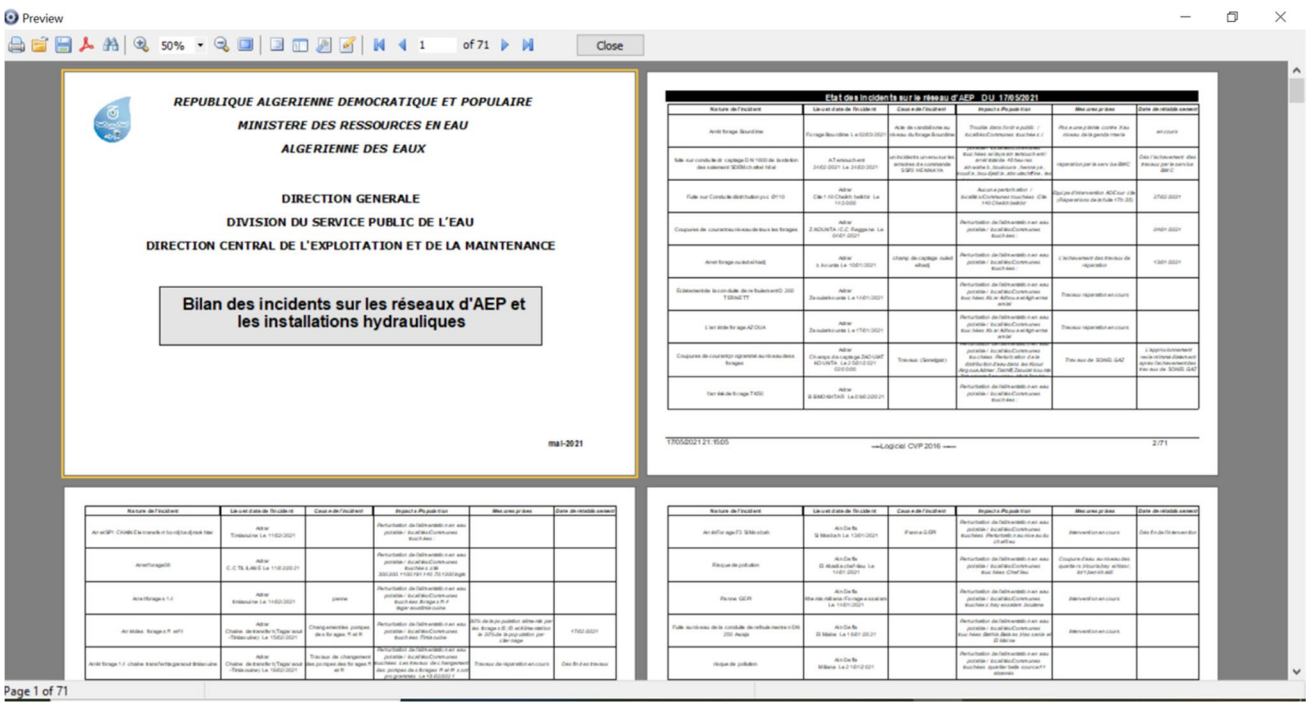

Figure. 11 Hydraulic incident state report windows

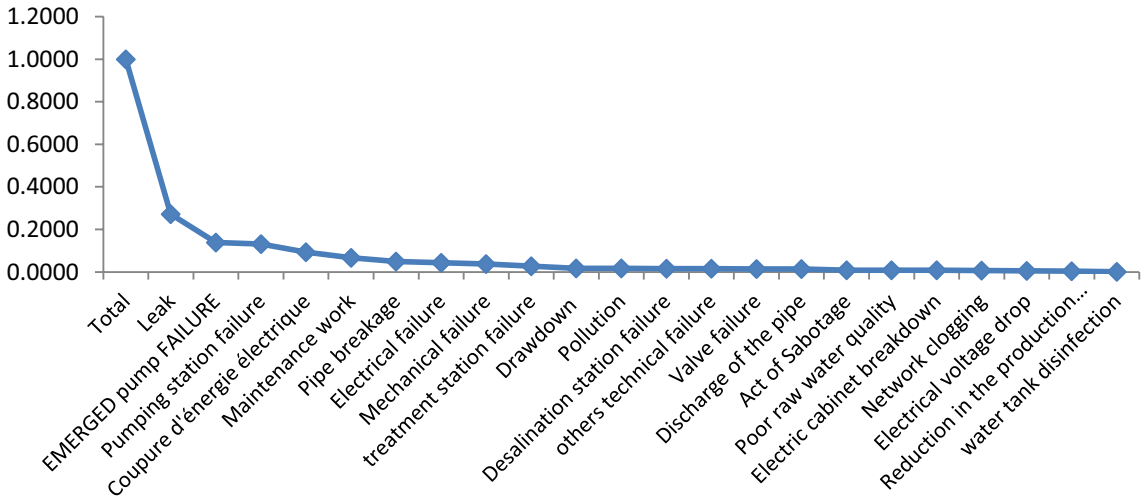

Figure. 12 Frequency of hydraulic incidents for the period 2016–2020

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data availability Data are provided in the supplementary materials.

Code availability We can give access to the software for any user with simple demand.

Declarations

Conflicts of interest Authors declare no conflict of interest.

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