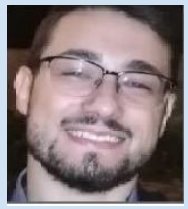
Optimal isolation valves positioning in water distribution networks and vulnerability assessment for maintenance routines scheduling



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Water Distribution Network modeling and management

Concept

Water Distribution Networks (WDNs) are generally subjected to several factors that make them susceptible to failures [1].
Failure of a single component of a WDN (e.g., pipeline, pump, valve, etc) could affect the system's performance in delivering water at the right quality and quantity. In this occurrence by closing the appropriate isolation valves the needed maintenance can be implemented.
In existing WDNs often only a limited number of isolation valves (ISO) is installed, therefore it is not always possible to isolate few pipes without leading to the isolation of a larger part of the network.
The quantification of node failure impact has been studied using vulnerability assessment methods. Different studies consider only generic topological aspects; furthermore, the possibility of air intrusion in pipes network, as a consequence of pipe failure, it is often not taken into consideration thus neglecting the consequent variations in the flow regime and pressure distribution.

Scientific approach

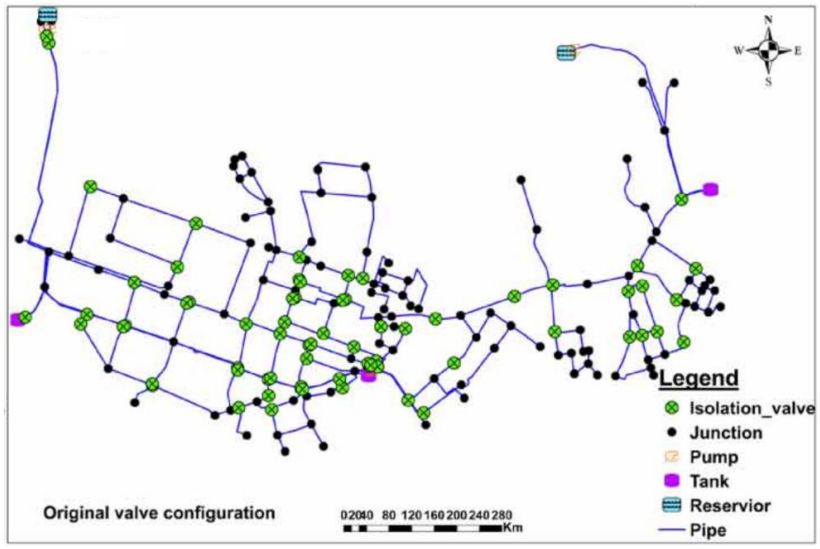
The main objective of the research project is to study and develop a model able to integrate topological and hydraulic aspects into network's vulnerability assessment: in particular, the model will be based on a more detailed modeling in the event of air intrusion in pipes, identifying the most severe impact-causing pipes and valve failures and taking into account number of isolation elements, the number of affected customers and the supply shortfall. In order to do so, a multi-objective optimization algorithm will be developed focusing on maximizing network's reliability and performances indices in the context of limited resources (valves) for maintenance.

Research objectives

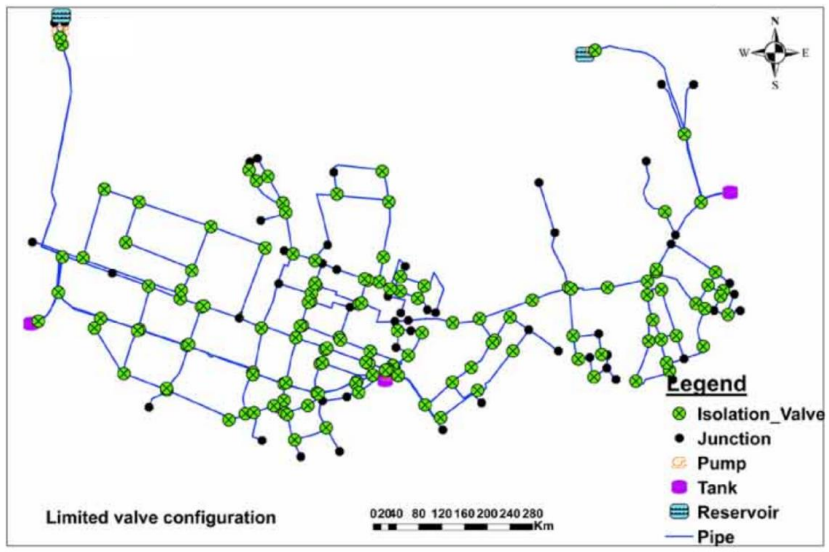
The new integrated hydraulic – topological model is expected to be able to optimize the design of existing and new WDNs through the installation of few isolation valves, minimizing WDN criticality ranking in the context of pipe failure. The model will consider the impact air intrusion has on flow regime and pressure distribution in the WDN and could help the decision-makers in the optimal positioning of isolation valves in the context of limited resources available for maintenance.

[1] Tornyeviadzi H.M., Hadi M., Razak S., Dynamic segment criticality analysis: A precursor to scheduling of maintenance routines in water distribution networks, Alexandria Engineering Journal (2022);

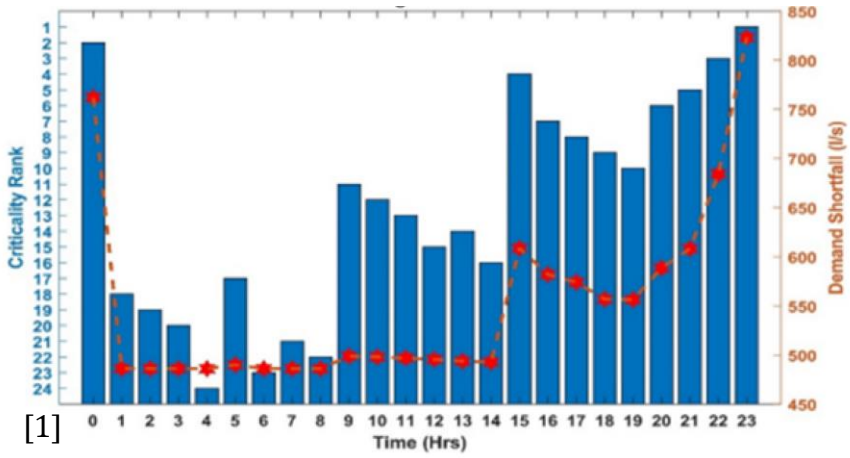
Analysis of water distribution network (WDN)



Optimization algorithm determines new WDN layouts



WDN perfomance indices improve and criticality ranking decreases



[1]