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# Analyzing Tabriz metropolitan drinking water utilities by using performance benchmarking

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**ABSTRACT**

Supply and maintenance of urban drinking water utilities are the most important priorities of people in the world especially in urban areas and it is very clear for urban planners or decision makers to evaluate the costs of action or weigh them against the problems of inaction. Also, specific annual budget is essential for ensuring people welfare and using water utilities with good quality. There are different issues in relation to managing of urban water utilities in terms of cultural, social, physical, environmental and even political and it is necessary to assess the existing conditions of utility by authorities and experts for making decision about those applications. So, we introduce Performance Benchmarking method for reaching this aim. This method is one of the best and update solutions in analyzing drinking water utility in developed countries especially in United State of America. So, in this paper, seven drinking water utilities of United State have been compared with Tabriz metropolitan drinking water utility that is located in North West of Iran and results of indicators' performance have been comparatively explained. Also, Results show that Tabriz metropolitan drinking water utilities are low advanced in terms of many indicators' performance than seven United States drinking water utilities. But, in some indexes almost equal to and in certain other cases are advanced than it. However, this methodology is very effective for decision makers, responsible and other experts in all regions and this model can be applied for other cities and urban areas.



## 1. Introduction

According to United Nation's projections, by 2050 almost half of the world's population will be experiencing either water scarcity (<1,000m3 of renewable water per capita per year) or water stress (between 1,000m3 and 1,700m3 per capita per year). It is estimated that 1 billion people in developing countries do not have access to portable water and unsafe water is implicated in the deaths of more than 3 million people annually and causes 2.4 billion episodes of illness from water-borne diseases each year (Oyegoke et al.2012). The world urban population was projected to increase from 6.7 billion in 2007 to 9.2billion in 2050(United Nations. 2008). 90% of this global entire population growth will take place in urban areas of developing economies (United Nations. 2004). Lacks of fresh water with good quality are the greatest challenges of civilization in the 21 century that threats social welfare, public health and ecosystems. So, reduction of water resources has been daily done in many countries in two ways including: historical evaluation and predicting of future in 1950 to 2010 that indicates these problems is very important and critical. In general, managing the needs to drinking water have been resolved the gap between supply and demand. reducing water harvesting in America properly confirm the Third World Water statement in Kyoto 2003 that the water crisis is not the lack of water but the problem is water management. At now, Tabriz metropolitan are faced with increasing demand for drinking water and limited water resources because of growing population trend. Because of the geographical location of Tabriz and the uncontrolled growth of water demand for new applications, water management organization of Tabriz city has faced with difficult situations, despite the use of adjacent water resources and construction of a new urban water infrastructure. So, it can be said that Tabriz urban water decision makers are faced with three major challenges in terms of water supplying for citizen. The first challenge is population growth and increasing water demand. The second challenge is funding for the implementation of water supply, transmission and demand management in inter-basin. And the third challenge is the lack of integrated management system in the metropolitan city of Tabriz and also in Iran. For example, due to lack of water infrastructure in some of the surrounding towns of Tabriz and especially in the Khavaran town in east of this city, the development and construction of these settlements are faced with many problems. Also, surplus Density selling by municipality of Tabriz causes other urban difficulties in this city. Nowadays, Managing and utilization of water resources and the creation, operation and maintenance of water and wastewater installations and structures, policy management, watershed and water resource development and management studies and planning water supply are important issues in all human societies. Therefore, research in this subjects and presenting techniques to improve this situation and conditions have particular importance in terms of training and research centers. The studies about water infrastructure show that these infrastructures are destroyed over time. These losses occur as a result of lack of proper maintenance and this issue itself primarily related to the finance budget and facilities. In general, experts suggest that the experience gained in the planning and development to maintain and enhancing the efficiency of the current situation and future development of drinking water infrastructure is

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urgent essential. But, for the maintenance and development of basic infrastructure, it is primarily needed to evaluate them. Such an assessment is possible only with performance benchmarking. Benchmarking is a tool for infrastructure managers and supervisors that it can be applied for all drinking water infrastructures in all states and cities to compare performance of them. However, learning and knowledge about indices to assessing ultimate performance of infrastructure and to better managing of them is necessary and very important. Benchmarking allows people who are not part of the utility to develop confidence that it is efficient and able to continuously improve. It also provides value in terms of cost and service by identifying factors that could delay potential improvement opportunities, prioritizing improvement opportunities, developing realistic timelines, and understanding the costs involved in completing any potential improvement. Ultimately, one of the outcomes of benchmarking is to ensure that the prices a utility charges its customers reflect efficient production costs. In general, the utility with the lowest price is not always the best performer (Berg et al. 2010).

## 2. Lesson from lectures

Benchmarking is popular and effective for performance evaluation not only in the water industry; there are many critical parameters for performance evaluation, and the types of parameters vary across industries, countries, and locations. A literature review reveals that if benchmarking practice is used efficiently, it can help water utilities improve overall performance. Many companies have experienced significant success in upgrading their organizational capabilities through benchmarking (Barber.2004) Benchmarking tools are important for documenting past performance, establishing baselines for gauging productivity improvements, and making comparisons across service providers (Berg et al. 2007). Cognitive, interest, values, and authority conflicts can be resolved when designing and implementing policies by using benchmarking for water utility performance, according to Berg (2006). Chen (2005) argues that service quality is an important factor in the water and sewer industries. Lin (2005), using data from the Peruvian water sector (1996–2001), examined how introducing quality variables affected performance comparisons across utilities. Corton (2009) conducted a comprehensive efficiency analysis of water utilities in six countries in Central America. The aim of that study was to provide policymakers and investment fund institutions with quantitative evidence of the effectiveness of regional water sectors and utilities from different perspectives. One conclusion of that analysis pointed toward additional efforts for improving data collection procedures in the region. According to an article by Dassler et al (2006), regulations are subject to available information, and lack of information may lead to inefficient allocation. A study by Shleifer (1985) considered the benchmarking approach by reporting on its actual use in UK regulatory bodies in telecommunications, water, and energy. There are very few studies related to Indian water utilities. None of the studies has evaluated a utility's performance using sustainability-related parameters. Singh (2010) attempted to fill this gap and suggested a sustainability-based benchmarking framework to assess the efficiency of 18 Indian urban water utilities using a data envelopment analysis approach. A few initiatives use subjective indicators; these can be eliminated by quantifying performance indicators. Most of the initiatives focus on one or a few areas of performance. A holistic evaluation of overall performance can be done using a comprehensive set of indicators that cover all major areas of a utility's performance. Very few benchmarking initiatives are web-based; this can be changed by creating a web-based benchmarking platform. Web-based benchmarking will provide a platform not only for data gathering, but also for providing utilities a platform for result visualization. (Rathor et al.2013)

## 3. Lesson from lectures

In this study, urban water drinking of infrastructure in Tabriz metropolitan in order to better managing have been investigated and analyzed by using benchmarking method. Benchmarking utility performance indicators is an essential element of continuous improvement, allowing utilities to track their own performance and to compare their results to peers to identify areas that could be strengthened (Rathor et al. 2013). This methodology has been applied in Tabriz metropolis in North West of Iran for the first time. But, Benchmarking methodology have been continuously applied by the AWWA. Also, performance indicators that involved in the water industry and organization are using to provide a suitable framework for the development of infrastructure in order to providing quality and effective management for drinking water. According to specified schedule, application process has been used to identified and executive defects (AWWA. 2008). In general, Benchmarking is a multistep process that needs to be carefully defined alongside a timeline to achieve the final goal. The process starts with selecting the subject and the practice. Data collection is performed using indicators that cover the major areas that contribute to overall performance. After defining the indicators, the next step is to define the data source and to develop the data collection process. The collected data are transferred to a common platform for analysis. The data are verified and analyzed, and results are produced. These results are validated with assistance from data sources and experts. The analysis results are used to determine potential gaps in performance and areas of underperformance. Goals are adjusted according to the analysis results, and improvement in future performance is targeted. The benchmarking process has been broken down into seven basic steps, as shown in Fig 1. (Rathor et al. 2013).

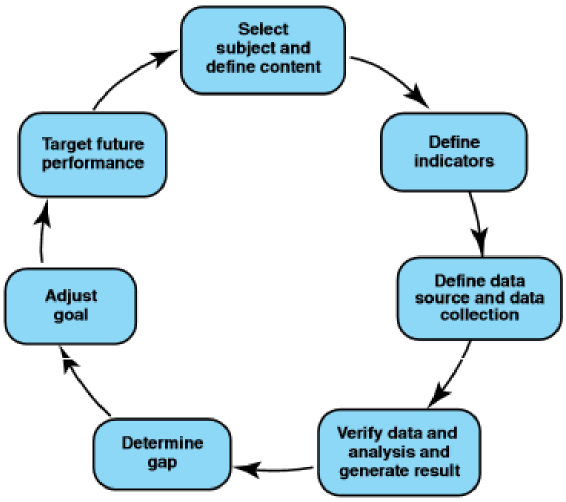


**Fig.1.** Basic Steps for Benchmarking (Rathor et al. 2013).

Also, the online platform known as the Water Infrastructure Database (WATERiD) was created so that utilities can compare their performance with similar-sized utilities and compare self-performance with that of previous years. The data were collected from utilities using benchmarking data collection sheets. This data collection was done using the web interface on WATERiD.

## 4. Results

Results of drinking water utilities of United State of America have been gathered from WateriD website. Also Tabriz Water Utility Data was gathered from Tabriz water and wastewater company. The performance indicators, methodology, and process of benchmarking were developed using research papers, books and reports on benchmarking done by various sectors. Total 89 indicators were used for data collection. Analysis results for few indicators have not been included because of the unavailability of enough data to make conclusions. The indicators were modified according to the aims and the needs pf this research. In general, for drinking water utility performance benchmarking the performance indicators are grouped under the following sections:

### 4.1. Eater resource utilization

Some utilities have a significant percentage of water loss (nonrevenue water) that is calculated as the percentage of treated water lost because of leakage and overflow. Most of the utilities do not reuse or recycle supplied water, even though reuse or recycling can help in conserving natural resources if done properly. In some areas, such as Florida, all wastewater is called recycled water in that it is pumped into groundwater aquifers to be used later. Availability of raw water resources varies for different utilities and depends on the geographic location of the utility. Some utilities are located in regions where extracting raw water does not require any permit and extraction is dependent on the capacity of intake structures. Other utilities are



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located at critical locations where there is a limitation on water extraction. The results of water resources in Tabriz and seven water utilities have been showed in Fig 2. However, Water resources generally are divided to three section including:1- water resources availability 2- reused supplied water 3- water lost. In Tabriz city water resources availability, almost is equal to average but reused supplied water indexes amount in this city is zero and this is a negative point for Tabriz utilities. Also, water lost indexes is greater than average and this is a negative point for that utility.

#### 4.2. Employee information

Employee-related indicators offer insight into how the participating utilities have staffed their utility, both in terms of leadership and operations; how they are structured in terms of employee levels; how they invest in their employees (e.g., training); and how they maintain a safe working environment. Alsharif et al (2008), Berg and Lin (2007), Mugisha (2007), Lin (2005), Lonborg (2005), Tupper and Resende (2004), Aida et al. (1998), and Lambert et al (1993) among others have used the number of employees (or labor or staff) as an input in their studies. The number of employees per 1,000 connections and per million gallons of water produced per day varies with a utility's size and location. Distribution of employees by percentage in upper management; human resources; financial and commercial; customer service; planning, design, and construction; and water quality monitoring was lower compared with percentage of employees in operations and management in all of the utilities. The number of employees in functions such as human resources and finance varies significantly between municipalities and drinking water authorities. In a municipality, many of these functions are provided by the general fund; the utility then disburses payment in lieu of taxes and/or transfers funds to the general fund for indirect costs. In a water authority, human resources and finance positions on usually on-staff positions. Most of the utilities invest significant time and resources on personnel training, most of which is safety-related. The percentage of employees injured is significant, indicating that better safety training is required. The rate of absenteeism from accidents is on the lower side for all the utilities. Results of Employee percent as per Function have been showed for Tabriz Metropolitan and seven case study in fig 3. It must necessary say that Greater management percent is more than average and in human resources indexes almost is equal to average. Also, financial, commercial and customer service indexes are greater than average. Result show, planning, design and construction indexes employee percent in Tabriz are very lower than average. Operation, maintenance and water quality monitoring indexes are very lower than average in Tabriz Metropolitan.

#### 4.3. Physical asset

A physical asset is any tangible item of economic, commercial, and/or exchange value and usually refers to cash, equipment, inventory, and/or properties owned by a business. Managing these physical assets is important for utilities to function properly. Quantifying the asset's performance and understanding the need for maintenance and replacement are important when managing any asset. Benchmarking has become a useful tool in the public debate over infrastructure compared with the treated water storage capacity. Most of the utilities shows a high value for this indicator, which implies that utilities produce more water than the storage capacity and pump it to customers as soon as the water is treated. Valve density indicates the number of valves per mile of main. The results for this indicator show that density for valves has a significant difference in value for different utilities. Hydrant density shows the number of water hydrants per length of main; this indicator value is in a similar range for all the utilities. Meter density shows the percentage of customers with meters. Most of the utilities have customer meters for almost all customers, showing a value close to 100 % for all utilities in the study. Density of valves and hydrants have been showed for Tabriz and seven water utilities of united states of America in Fig. 4. Also, the results indicate that percent of valves and hydrants are lower than average and median in Tabriz.

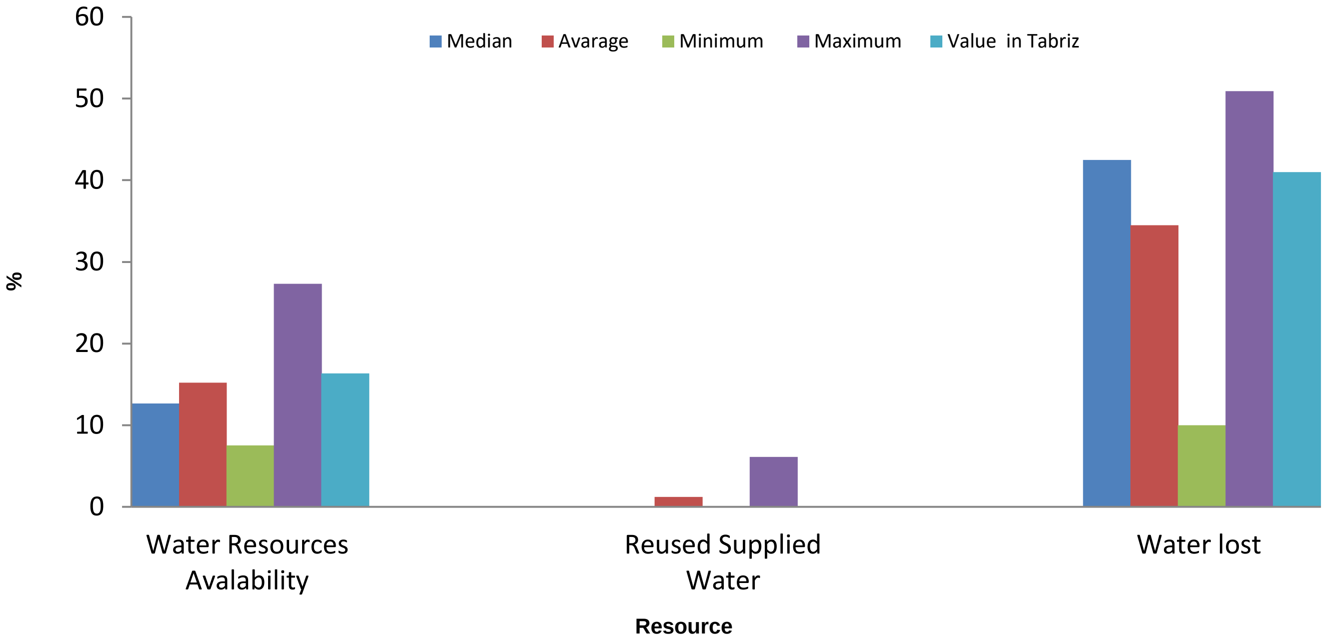


**Fig. 2.** Indicators Related to water resources.

#### 4.4. Service quality

Service quality is a very important aspect of the water industry (Chen. 2005) and is a vital component in a utility's ability to maintain profitability and success. Population coverage provides the percentage of population served in the service area; for most of the utilities, this number is high. Main breaks show the number of main breaks in every 100 mi of mains in the past year and how the mains have been maintained. A few utilities have a higher number for this indicator (29 main breaks per 100 mil). Limiting water interruptions is a critical part of service because a higher number of interruptions causes higher customer dissatisfaction. Percentage connections with interruption in service show that most of the connections that experienced interruption were < 4 h, showing that most of the utilities solved the water interruption on a priority basis. Quality of supplied water is the most critical indicator in evaluating the quality of service. Before supplying the treated water, many required tests defined in water standards must be performed. The water quality indicators were divided into two



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categories: the total percentage of tests compliant with the standards for treated water and the total percentage of required tests done. These indicators summarize the total percentage of tests compliant with the standards and total percentage of required tests done. Most of the utilities surveyed perform more than the minimum number of required tests, and most showed an almost 100% compliance with permit conditions for the tests. Percentage of Tests complying with the standard in Tabriz water utility and seven water utility of United States of America have been showed in Fig 5. Results indicates that the amount of total, Aesthetic, Microbiological and physical- chemical tests in Tabriz city and seven water utilities of united states of America are almost equal but the percent of Radioactive test in Tabriz city is very lower than seven water utilities of united states of America.

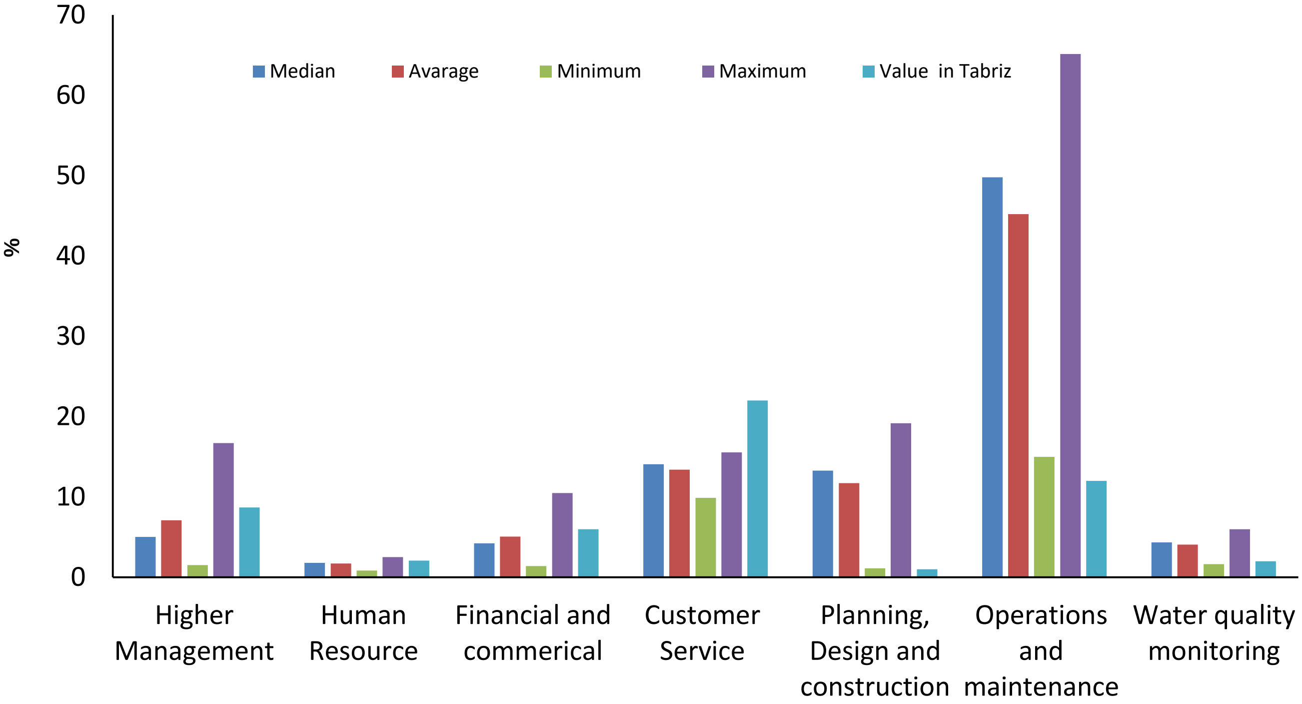


**Fig. 3**. Employee % as per function.

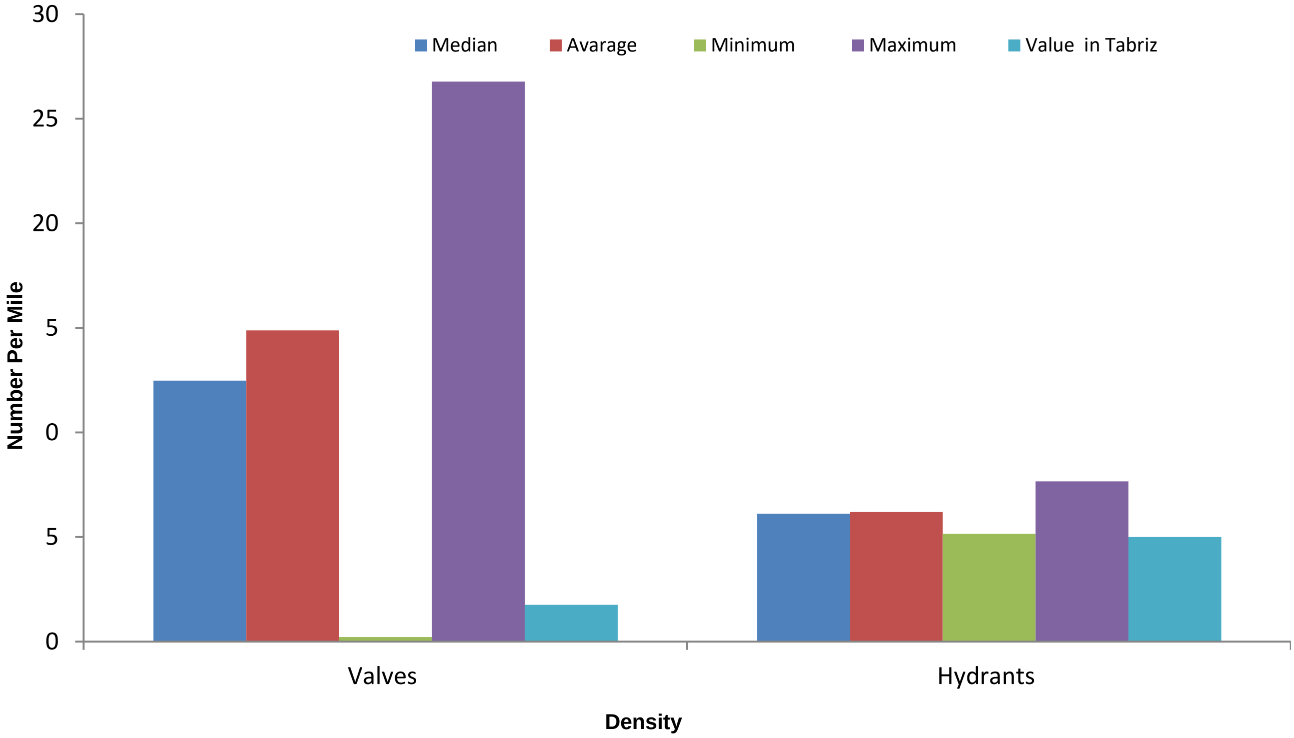


**Fig. 4.** Density of Valves and hydrants.



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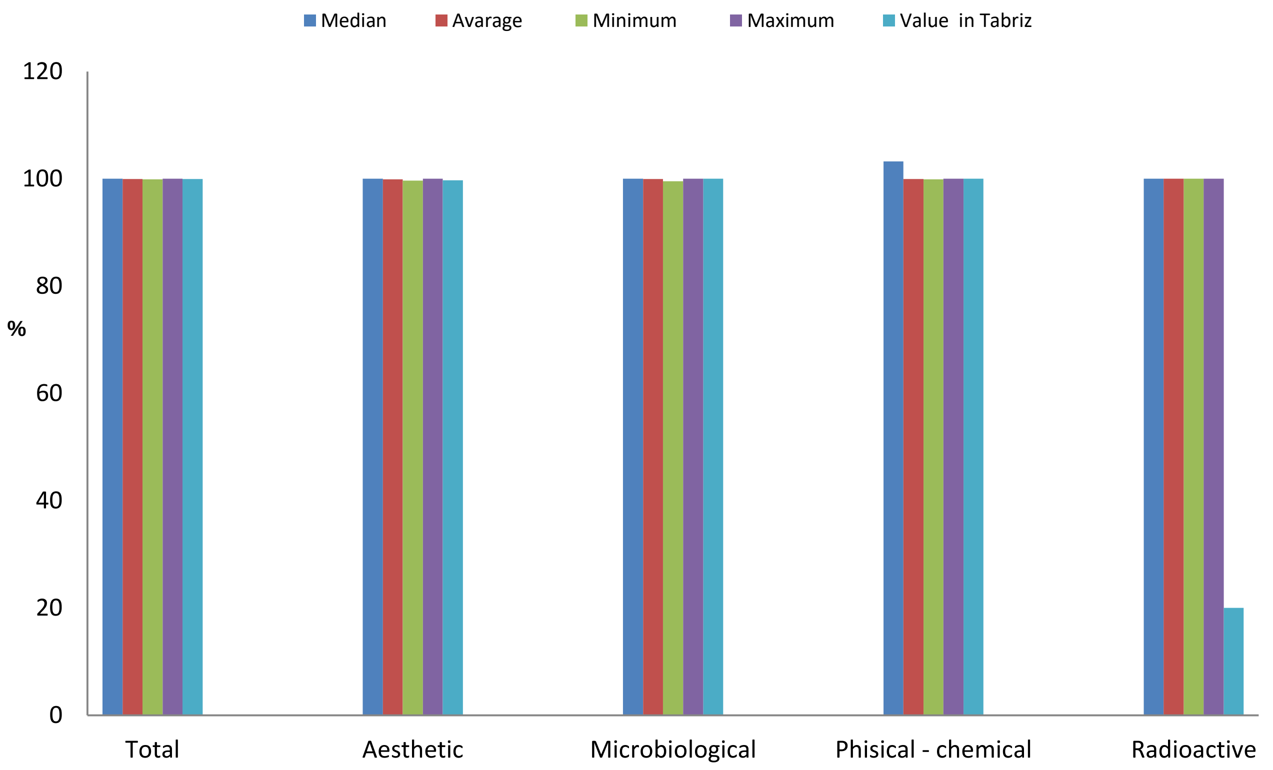


**Fig. 5.** Percentage of Tests complying with the standard.

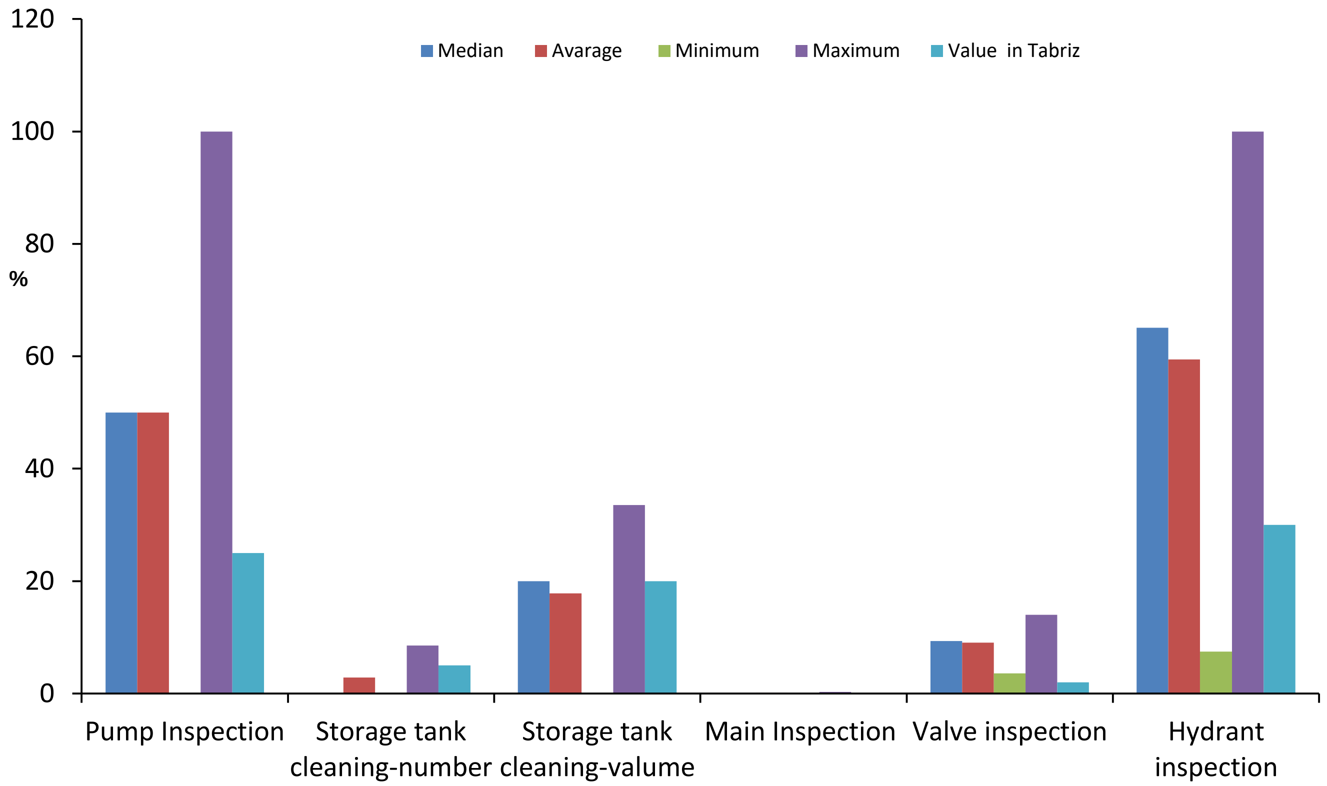


**Fig. 6.** Percentage of physical asset inspection and maintenance.

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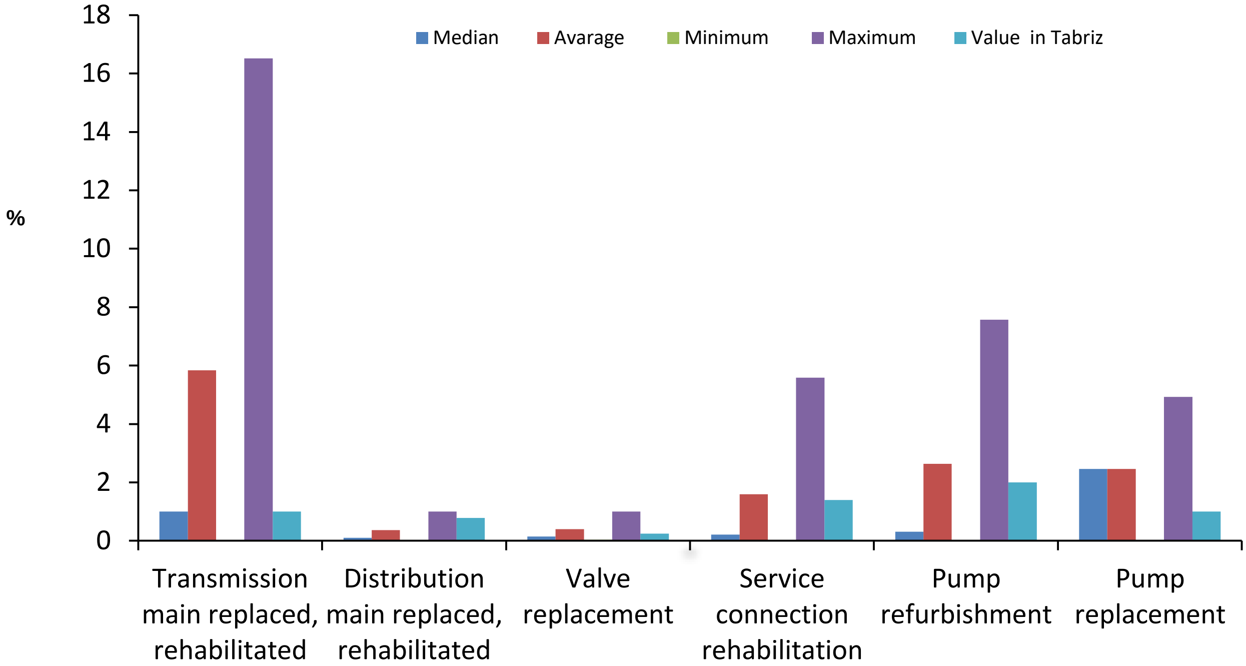


**Fig. 7.** Percentage of different type of operational performance.

### 4.5. Operational performance

Those responsible for utility operations can only manage what they measure, so having information on productivity trends and relative performance enables utility managers to direct attention to shortfalls (Berg et al. 2007). The indicators for operational performance evaluate efficient use of resources, reliability, inspection of current assets, rehabilitation of existing assets, and losses from low operational performance. Inefficient or ineffective operations lead to higher costs, which in turn lead to higher sales revenue needs. Pump inspection shows the percentage of existing pumps inspected. A few utilities inspected all their pumps, whereas some utilities did not inspect any pumps in the past year. Storage tank cleaning shows the percentage of tanks cleaned in the past year. This indicator shows a lower number: about one quarter of all storage tanks are cleaned every year, indicating that most of the utilities do not clean all their storage tanks every year. Main inspection shows the percentage length of main inspected. The values indicate that no utility focuses on inspecting the mains; the value for this indicator is close to zero for all utilities. One participating utility specified that inspection techniques for buried pressure pipe were too costly for regular use. Instead, that utility uses a criticality matrix in which pipe segments are ranked ranging from a low likelihood of failure and low consequence of failure up to a high likelihood and high consequence of failure. This matrix considers pipe age, pipe material, previous failures, and consequences of failure. For example, a main transmission pipeline that provides service to a hospital will have a much higher consequence from failure than a distribution line serving five houses on a cul-de-sac. Results for valve inspection show that most of the utilities do not inspect valves on a regular basis and merely change them whenever a problem occurs. Hydrant inspection shows the percentage inspected; the results for this indicator show that a few utilities inspect all the hydrants every year whereas others do not, instead replace hydrants when they stop working. The results for physical asset inspection and maintenance are showed in Fig. 6. Indicators for rehabilitation such as leakage control show the number of main breaks detected and repaired per 100 mi of main. Many utilities showed the value of this indicator in the percentage of meters that are working; all the utilities show a number close to 100 % for this indicator. Unmetered water shows the percentage of water that is not metered; utilities show an average value of 10% for this indicator. Results show in pump inspection, valve inspection and hydrant inspection indexes Tabriz drinking water utility is lower than average and median in seven drinking water utilities in united states of America. Also, Fig. 6 indicates storage tank cleaning-number and storage tank cleaning-volume is greater than average and median Water loss includes water lost through leaks, breaks, backwash, flushing, and under registering meters. Water loss per connection and percentage of water lost that was treated in the past year indicates a range of 8–27 %. Water loss is a concern for every utility. Some nonrevenue water can be attributable to a poor meter replacement program because meters tend to under register as they age. The operational meter’s indicator showed in the Fig. 7 indicates percentage of different type of inquiries indexes. In this figure, transmission main replaced, rehabilitated, distribution main replaced, rehabilitated, valve replacement, service connection rehabilitation and pump refurbishment indexes information have been introduced for Tabriz drinking water utilities and seven water utilities of united states of America. Also, the amount of transmission main replaced, rehabilitated, valve replacement, service connection rehabilitation and pump refurbishment indexes value in Tabriz water drinking utilities is lower than seven water drinking utilities in United States of America. Also, percentage of distribution main replaced, rehabilitated in Tabriz water drinking utilities is greater than seven water drinking utilities in United States of America.

### 4.6. Customer enquiries

Customer satisfaction is a measure of how services supplied by a utility meet customer expectation. Customer satisfaction is defined as “the number of customers, or percentage of total customers” whose reported experience with a firm, its products, or its services (ratings) exceeds specified satisfaction goals (Farris. 2010). In a survey of nearly 200 senior marketing managers, 71% responded that they found a customer satisfaction metric useful in managing and monitoring their businesses (Farris, 2010). Customer satisfaction is viewed as a key performance indicator within business and is often part of a balanced scorecard. In a competitive marketplace in which businesses compete for customers, customer satisfaction is a key differentiator and increasingly has become a key element of business strategy (Gitman. 2005). Service inquiries per 100 connections show total inquiries in the past year per 100 connections; the value is in the 0.5–4.1 range. Inquiries were further divided by type: percentage of pressure related reports, percentage of continuity-related reports, percentage of water quality/taste-related reports, percentage of water quality/ odor-related reports, and percentage of interruption-related reports. Pressure of water supply, continuity of water, and interruptions are the most customer-reported categories. Fig 8. indicates percent of different type



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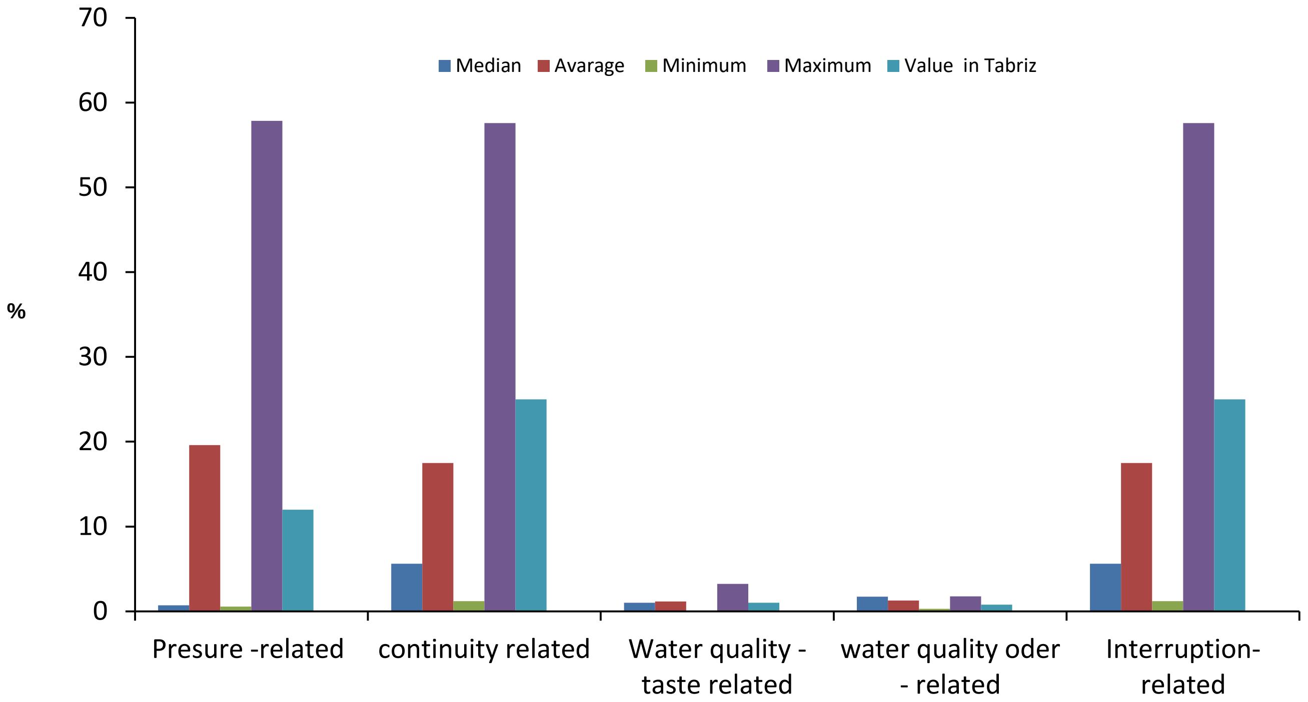


**Fig. 8**. Percentage of different type of customer inquiries.

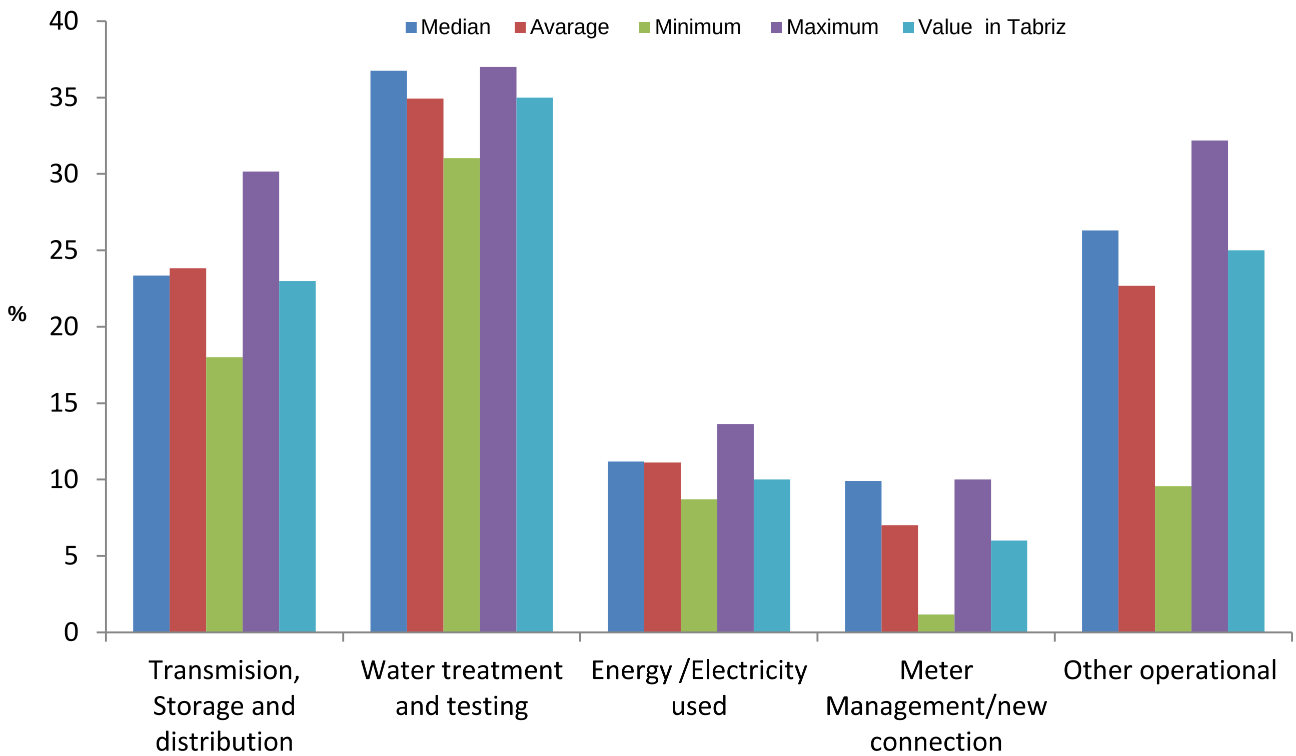


**Fig. 9.** Percentage of different types of operational cost.



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**4.7. Financial performance**

Financial results are reflected in the utility's return on investment, return on assets, value added, total cost, revenue generated, cost coverage, and profit. Financial performances a measure of how well a utility can use assets from its primary mode of business and generates revenues; it is also used as a general measure of a utility's overall financial health over a given period and can be used to compare similar utilities. Consideration of financial sustainability includes examining how the role of collections, revenues, and operating expenses affect overall performance. Key financial ratios should serve as indicators of long-term performance because revenues used to facilitate future capacity investments for both network expansion and external funding can be contingent on current cash flows more than covering operating expenses (Berg et al. 2007). The indicators for the revenue section summarize revenue per million gallons of treated water produced. Revenue is further divided into percentage of sales revenue and percentage of other revenue. The largest percent of revenue comes from sales for all the utilities. The cost indicators summarize total cost per million gallons of treated water produced, capital cost per million gallons of water produced, and operating cost per million gallons of water produced. The summary of percentage of operation cost is shown by the type of operation. The percentage of operational cost for transmission, storage, distribution, and water treatment and testing shows higher values; this result was expected because these are utilities' main functions. Investment indicators summarize total investment per million gallons of water produced, percentage of investment on new assets, and percentage of total investment on replacement and renovation. For all the utilities, the majority of investment is for new assets. The rate a utility charges the consumer changes depending on the cost of treatment and operation. Total cost coverage, operational cost coverage, liquidity ratio, asset turnover ratio, and water loss cost (nonrevenue water) are efficiency indicators. some utilities are experiencing reduction of demand; this is expected to continue, although population is expected to increase. The various factors contributing to lower demand includes conservation programs, water and sewer rates, and improved system operations. One utility reported that in the past five years the average household consumption decreased from 6.53 ccf (4,880 gal) per month to 5.62 ccf (4,200 gal) per month. Although from a conservation standpoint, this is perceived as a good thing, it is creating significant challenges for utilities. Revenues in both water and sewer funds decreased by approximately $1 million in the past year. The utility's city council was reluctant to raise water and sewer rates in this economic climate, and any increases they approved could only cover rising operational costs. As a result, the utility had to significantly cut back its capital improvement programs—from $20–25 million to $2–3 million in the sewer fund at a time when infrastructure investment is critical for long-term sustainability. All the results for the indicators can be accessed using the WATERiD website (www.waterid.org). Also, percentage of different types of operational cost indexes such as: transmission, storage and distribution, water treatment and testing, energy/ electricity used, meter management/new connection and other operational have been showed in fig 9. Results indicates values of transmission, storage and distribution, water treatment and testing, energy/electricity used and it is clear the amount of meter management/new connection indexes in Tabriz drinking water utilities is lower than median and average of seven water utilities in united states of America and the amount of other operational indexes are greater than average and median.

**5. Conclusions**

Results show, planning, design and construction indexes employee percent in Tabriz are very lower than average. Operation, maintenance and water quality monitoring indexes are very lower than average in Tabriz Metropolitan. Also the results of this paper indicate that performance assessment of Tabriz utility water system are very effective for managing of water network of Tabriz and planning for future needs of citizens. Also, this method introduces techniques for experts and to have a better and efficient management for welfare and security of our people in the future. Also, this method introduces techniques for experts and decision makers to create developmental plans with the correct analysis. In addition to, this technique has been applied for identifying weakness and strength points of water drinking water utilities of Tabriz city in North West of Iran for the first time.

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