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Survey of heterotrophic bacteria population changes in Kerman drinking water distribution system and GIS zoning

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ABSTRACT

One of the effective methods for water quality monitoring in drinking water distribution system is heterotrophic bacteria population count. The aim of this descriptive and analytical study was done at July 2010 to June 2011 was survey of the Kerman city (in Kerman province, center of Iran) drinking water distribution system monitoring, the variation of heterotrophic bacteria population and related parameters such as Turbidity, pH, residual free chlorine and Temperature. According to population amount and density of Kerman city, 74 sampling points of Kerman drinking water distribution system was selected and samplings were performed monthly. In all points, HPC, pH turbidity, residual free chlorine were measured according to standard methods for water and wastewater examinations. The obtained results were analyzed by SPSS software and zoning of variations was done on Kerman map by GIS. The annual average of HPC, residual free chlorine, temperature, turbidity and pH were respectively 19.8 cfu/ml, 0.42 mg/L, 24.9 °C, 0.58 NTU and 7.57. ANOVA analysis showed that between average of HPC, residual free chlorine, temperature and turbidity at different months and seasons there are significant differences ,also Correlation test showed that a significant relatives between studied parameters was obtained by Pearson's coefficient(P_{value}<%5). Data zoning showed high amount of HPC at network blind spots that it's related to low residual free chlorine concentration and high turbidity. The average of HPC, pH, turbidity and residual free chlorine in Kerman drinking water distribution system are in line with WHO standards. In blind spots and terminal points of Kerman drinking water distribution system, measured residual free chlorine is lower than WHO standards. At summer, lower pressure of distribution system was created negative pressure, external material entrance and turbidity increasing that is enhanced negative effects that must be considered.

Keywords: Heterotrophic bacteria, Drinking water, Distribution network, Zoning

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INTRODUCTION

Monitoring the drinking water distribution networks play an important role in providing clean water programs and should include parameters that can reveal potential contamination (failure in distribution system) and the pollution is real [6]. Drinking water distribution networks for various reasons can cause water quality to be decline. Storage tanks due to defects, accidents and defects in distribution networks. Counting and determination of bacterial populations in water distribution network may be reduced in water quality and identify potential factors affecting its reduced. Microbial population over the distribution network in terms of influence on the health of consumers, especially vulnerable group of microbial were considered [7]. For continuous monitoring of water quality in distribution networks, heterotrophic bacteria plate count (HPC) as an index widely used [9]. Heterotrophic (Heterotrophic) as microorganisms that require organic carbon for growth have to be identified. These aerobic microorganisms, anaerobic - are optional. Bacteria, yeasts and fungi are among them. These bacteria naturally are consumed organic carbon as carbon source, living in the lant Leaves, soil, water, rain droplets and saliva. The growth of bacteria in distribution networks depends on physical and chemical conditions, as well as how to exploit seasonal fluctuations [11]. Other factors can affect the remaining free chlorine, organic carbon absorbance (AOC), water temperature, pH, type of pipe, corrosion and biofilms formed in the presence of fluid flow tubes have been by mentioned [12]. Some networks also long distance between home and place treatment that increase retention time in the water distribution network is, electrical/conductivity and turbidity of water also measured [13]. America Environmental Protection Agency threshold colony forming unit's in500 ml (cfu/ml) as a benchmark when monitoring exploits HPC offers [14]. In the German country in less than 100 colony units of ml (cfu/ml) for heterotrophic bacteria plate count to ensure consumer health is considered [12] In cases where heterotrophic bacteria counts more than 250 colony forming units of ml (cfu/ml) is drawn washing the network [13].. According to the America Environmental Protection Agency(EPA) because increased heterotrophic bacteria plate count (HPC) associated with increased fecal contamination is possible, therefore, heterotrophic bacteria plate count (HPC) on a reliable index of fecal contamination is not considered distribution network [16 and 10]. However, counting and determining the role of heterotrophic bacteria plate count (HPC) in drinking water quality management as a performance indicator of appropriate water treatment, water supply and distribution systems, drinking water, acceptable (smell and taste) as well as criterion for the regrowth of microorganisms pathogenic and non pathogenic in water distribution networks and water reservoirs and thus public health is undeniable. The index of the bottled water industry, water circulating in trucks carrying food and water and water stored in ships and aircraft to determine the need to wash tanks and also determine the network and work network and came washing tanks are used [5 and 17].Excess bacterial activity in water deteriorate the quality (taste, smell, favore) and can interfere with other methods used by health indicator for monitoring major parameters [20], and show some defects in filtration and water distribution system[6]. HPC can serve as a control tool for awareness of the conditions of storage system distribution as growing biofilms in the pipes that can cause biological corrosion and blockage of pipes and reduce discharge and good place for grow of microorganisms to protect against disinfection. Need to wash networks in high efficient and help determine the index. Also, estimation of microbial population density due to interfere with fermentation of lactose by the bacteria may be high, the main indicators of water pollution, including fecal coliform and Escherichia coli may be determine. Above counting heterotrophic bacteria can correct the distributing systems that have special role for defects in treatment facility, transmission, storage and distribution of water and effective action to eliminate these defects.

MATERIALES AND METHODS

Study site description

Kerman drinking water distribution network of approximately 1600 km long and more than 120,000 branches, totaling a population of drinking water supplies to 500,000 populations. High life and deterioration network, the possibility of infection by distribution network, particularly in terms of creating negative pressure in the network increases. Too long, the branch distribution network design in some parts of city can increase water retention time at the end of the network. Variable weather conditions, especially high temperatures in the summer makes better conditions for growing bacteria prepare heterotrophic. High temperatures accelerate the remaining chlorine in the exit from the network that fit resonator for growing microorganisms. With determination and knowing the index and its related factors can clarify many difficult is of water distribution network. With this aim, the study of water distribution network was conducted in province Kerman.

Field measurements

This study was conducted in the period of June 2009 to June 2010.Considering the level and population density of HPC, pH, turbidity, free chlorine, 74 samples in the distribution network were selected monthly. Each sample was analyzed according to standard procedures by Neutralize chlorine 250 ml added to10% sodium thiosulfate unsterile bottles the samples were shaked and mixed prior to testing. Samples were collected under standard conditions in the vicinity of the ice and transported to the laboratory and tested. Analysis of performed by data Excel and SPSS software, and Pearson correlation were used one way Anova. Zoning for distribution network based on heterotrophic bacteria population studies regarding the first GIS software was done. Topographic maps produced by the city and sampling points were identified and coded and recorded according to GPS device and associated map. The results of the experiments placed in different categories and GIS database used for incorporation into outrance operation by map.

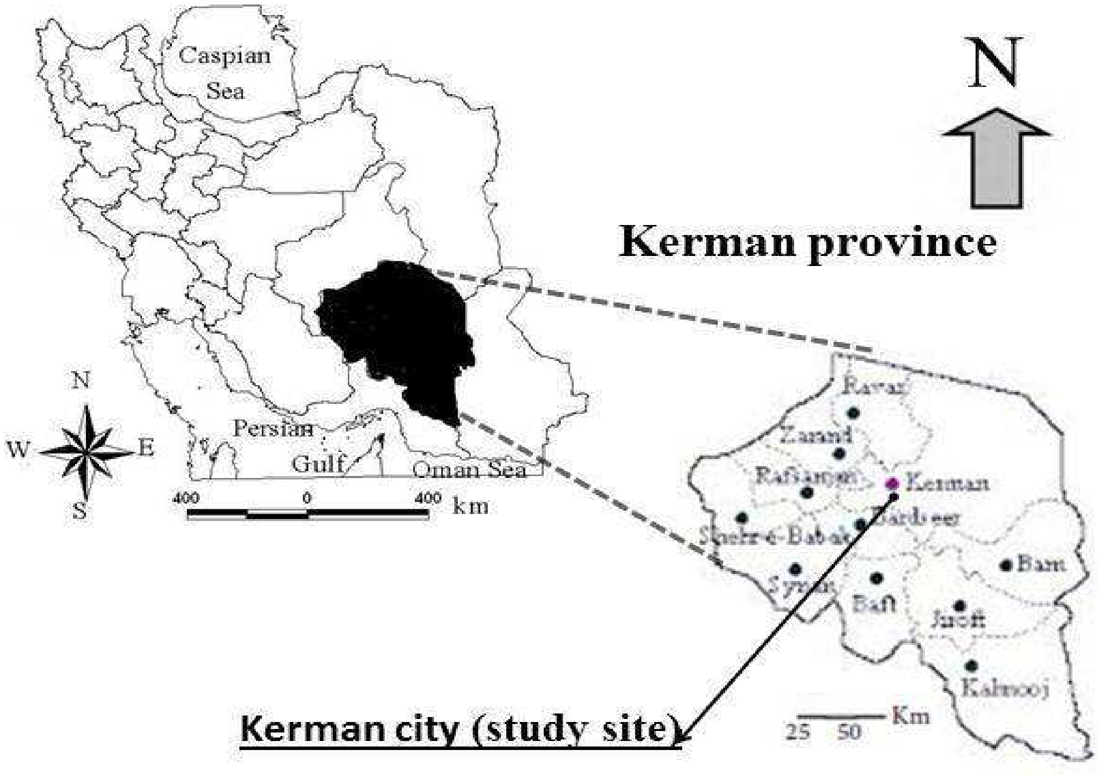

Figure 1. Study site location in the Kerman Province, central Iranian state of Iran.

RESULTS AND DISCUSSION

Table 1: average, minimum and maximum HPC parameters turbidity, turbidity, pH, temperature and free chlorine remaining in the different months of the year:

Parameter	Time Variant	July	august	September	October	November	December	January	February	march	April	may	June
HPC (cfu/ml)	mean	33.43	26	29.5	26.82	17.35	19.89	8.94	10.62	8.25	10.58	23.93	21.57
	SD	51.55	43.5	51.7	40.28	40.49	42.7	9.82	21.20	24.55	20	61.25	45.2
	min	3	2	2	2	1	0	1	1	1	1	1	2
	max	256	226	261	255	261	206	61	117	210	127	400	250
Turbidity (NTU)	mean	0.659	0.59	0.63	0.621	0.58	0.59	0.489	0.57	0.51	0.58	0.59	0.654
	SD	0.37	0.29	0.39	0.36	0.27	0.35	0.24	0.24	0.24	0.258	0.294	0.38
	min	0.24	0.25	0.24	0.221	0.23	0.21	0.20	0.24	0.21	0.23	0.18	0.25
	max	1.69	0.134	2.13	2.1	1.92	2.11	1.1	1.4	1.58	1.51	1.67	1.54
pH	mean	7.73	7.56	7.37	7.53	7.45	7.55	7.5	7.7	6.87	7.64	7.5	7.66
	SD	0.16	0.23	0.18	0.21	0.23	0.22	0.28	0.19	0.137	0.2	0.26	0.25
	min	7.12	6.88	6.7	6.89	6.85	6.8	6.8	7.29	7.4	7.1	6.8	7.51
	max	8.2	8.3	7.65	8.1	7.99	8.1	8.1	8.3	8	8.1	8.2	8.1
Temp c°	mean	25.56	26.25	24.45	20.32	19.5	18.3	17.05	16.77	17.47	18.72	20.71	25.62
	SD	1.17	1.72	1.21	1.61	1.59	1.18	1.21	1.35	1.51	1.08	1.43	1.54
	min	23	24	22	18	18	17	15	16	15	17	18	18
	max	28	31	27	25	23	21	21	20	21	22	23	28
CL (ppm)	mean	0.416	0.409	0.406	0.542	0.574	0.491	0.502	0.47	0.57	0.493	0.477	0.504
	SD	0.132	0.118	0.126	0.158	0.129	0.99	0.11	0.101	0.121	0.91	0.11	0.121
	min	0	0.1	0	.01	0.1	0.3	0.3	0.1	0.3	0.1	0.1	0.3
	max	0.7	0.6	0.7	0.8	0.8	0.8	0.8	0.7	0.9	0.7	0.7	0.8

According to table 1 results showed the highest and lowest values of parameters HPC there consecutively was: in may and December (400 cfu/ml at port No 4 and 0 cfu/ml at port No 68), Turbidity: in September and May (2.13 at port No 1 and .18 at port No 66), pH: in February , august and September (8.3 at ports No 5 ,63 and 6.7 at port No 51),Temperature: in august, January and march (31^0 at port No 34 and 15^0 at ports No 7,2,1,50) ,Residua chloric: in March and July, September(0.9 ppm at port No48 and 0ppm at ports No 63 and 74). Average review time parameters measured in different months shows HPC index in July with average 33.43 cfu/mL maximum and in march with average 8.25 cfu/mL minimum, Turbidity in July with average 0.659 maximum and in January with average 0.49 lowest, PH in July averagely 7.73 maximum and in march mean 6.87 the least, the remaining chloric in November with average 0.574ppm maximum and in September with average 0.406 ppm are the lowest. In all cases come the WHO guidelines with maximum to 5 NTU. But %6.3 of total samples was higher than EPA standards (1 NTU). Monthly trend and seasonal variations show that turbidity in summer and July had a significant difference with other months and seasons, that causes can be shock by negative pressure in network and increase of suspended material and release the biofilm in water and positive impact on microbe population in high temperature.

Table 2: average, minimum, maximum of parameters (HPC turbidity, pH, temperature, and free chlorine remaining in different seasons)

Parameters	Time / Variant	Summer	Autumn	Winter	Spring	year
HPC (cfu/ml)	Mean	29.62	21.34	8.94	19.34	19.8
	SD	48. 75	41.84	19.17	44.77	38.63
	Min	2	0	1	1	1
	Max	261	261	210	400	283
Turbidity (NTU)	Mean	0.629	0.603	0.53	0.595	0.588
	SD	0.35	0.33	0.24	0.28	0.301
	Min	0.24	0.21	0.21	0.18	0.21
	Max	2.13	2.11	1.58	1.98	1.95
PH	Mean	7.55	7.51	7.61	7.63	7.57
	SD	0.24	0.22	0.22	0.25	0. 23
	Min	6.8	6.85	6.8	6.8	6.812
	Max	8.2	8.1	8.2	8.2	8.175
Temp c°	Mean	42.25	19.4	17.1	20.9	24.91
	SD	1.57	1.68	1.39	2.26	1.751
	Min	22	17	15	17	17.75
	Max	31	25	21	26	25.75
Cl (ppm)	Mean	0.401	0.473	0.514	0.321	0.426
	SD	0.125	0.132	0.12	0.1	0.119
	Min	0	0	0.1	.01	0.25
	Max	0.7	0.8	0.9	0.7	0.77

According to table 2 the average seasonal index HPC at summer (29.62*cfu /ml*) and in winter (8.94 *cfu/ml*) had the lowest content. Turbidity in summer (0.629 NTU) and in winter (0.53 NTU) had the lowest content. Winter pH (7.63) and autumn most (7.51) had the lowest content. Summer temperatures (42.25 °C) and in winter (17.1 °C) had the lowest content. Free chlorine residue in the winter (0.514 ppm) and summers (0.401ppm) was the lowest average. Annual average parameters HPC, Turbidity, pH, Temperature and residual chlorine consecutively were 20.44 cfu, 0.58 NTU, 7.56, 20.7 °C and 0.468 ppm.

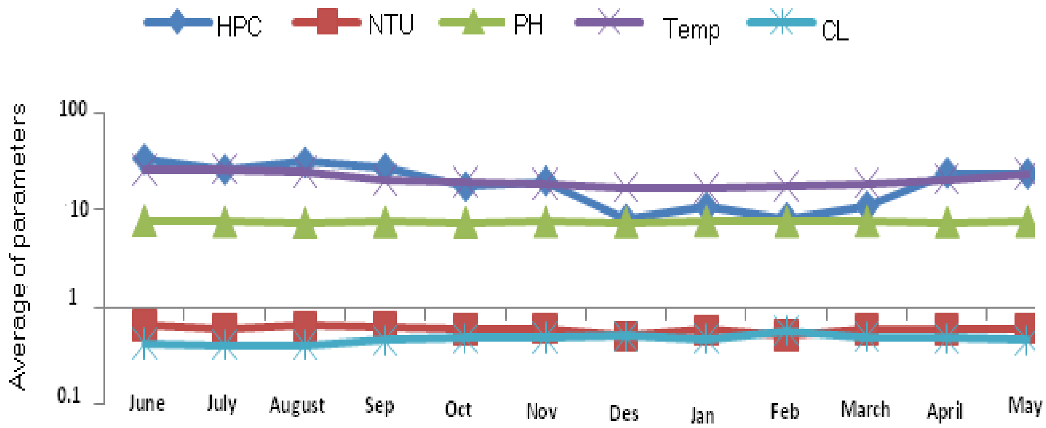

Figure 2: Average monthly changes in (HPC, turbidity, pH, temperature and residual chlorine)

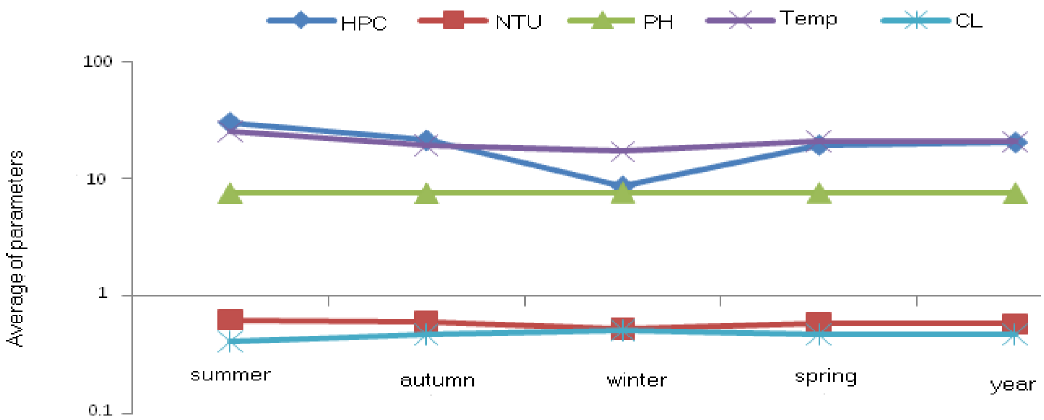

Figure 3: Average seasonally changes in (HPC, Turbidity, pH, temperature, residual chlorine)

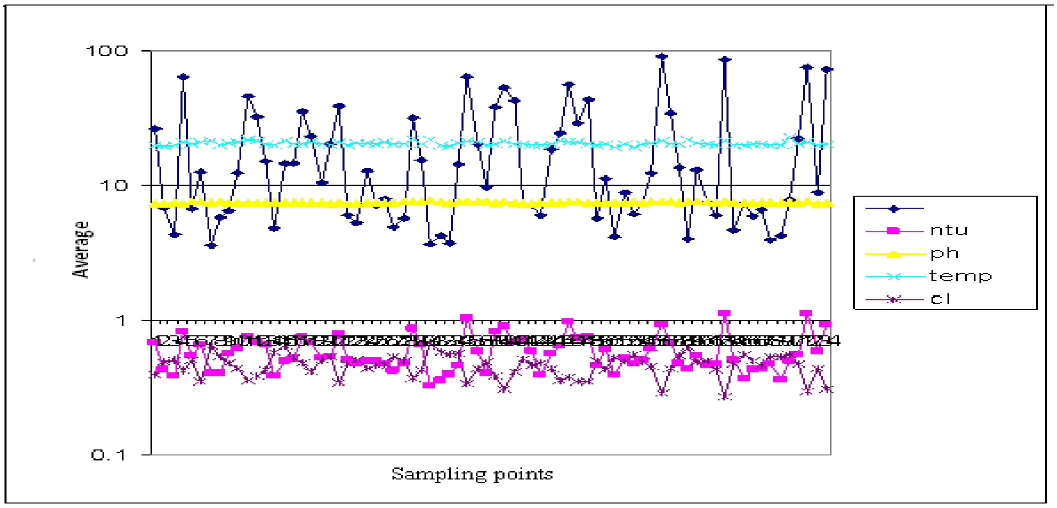

Figure 4: Average annual changes chart Logarithmic HPC, Turbidity, pH, Temperature, residual Chlorine in different parts

Average monthly trend change of measured parameters is compared in figure 2. In figure 3 the process of seasonal change in parameters were compared. In figure (4) changing in the mean annual sampling points showed the greatest amount of turbidity, HPC, pH, respectively temperature and residual chlorine. Results of One-way ANOVA test to compare mean differences of measured parameters in different months shows between the average volume of HPC (P_{value}= 000, F=3.77) and pH (P_{value} = 000, F=15.77) and temperature (P_{value}= 0.01, F= 4.437) in different months in 2005 had a significant difference. But the average turbidity in different months had not significant difference (P_{value}= 0. 084, F=1.634). In different seasons all parameters except turbidity has also a significant difference. In comparison of parameters measured in the annual distribution networks and reservoirs Results of Pearson correlation analysis showed that between HPC and turbidity parameters has a direct significant relationship (P_{value}=.023, r = 0.758), and with temperature due to effect on microbial growth has a direct significant relationship (P_{value}= 0.009, r= 0.595), and with residual free chlorine has inverse significant relationship (P_{value}= 000, r= -0.818). Also between temperature and residual free chlorine since the high temperatures accelerate residual chlorine removal in the water, there was reversed significant relationship.

Figure 5 showed that the between PH and HPC there was no significantly associated, but with free chlorine remaining by 0.05 opacity level and with temperature by 0.01 opacity level there were significant direct correlation.

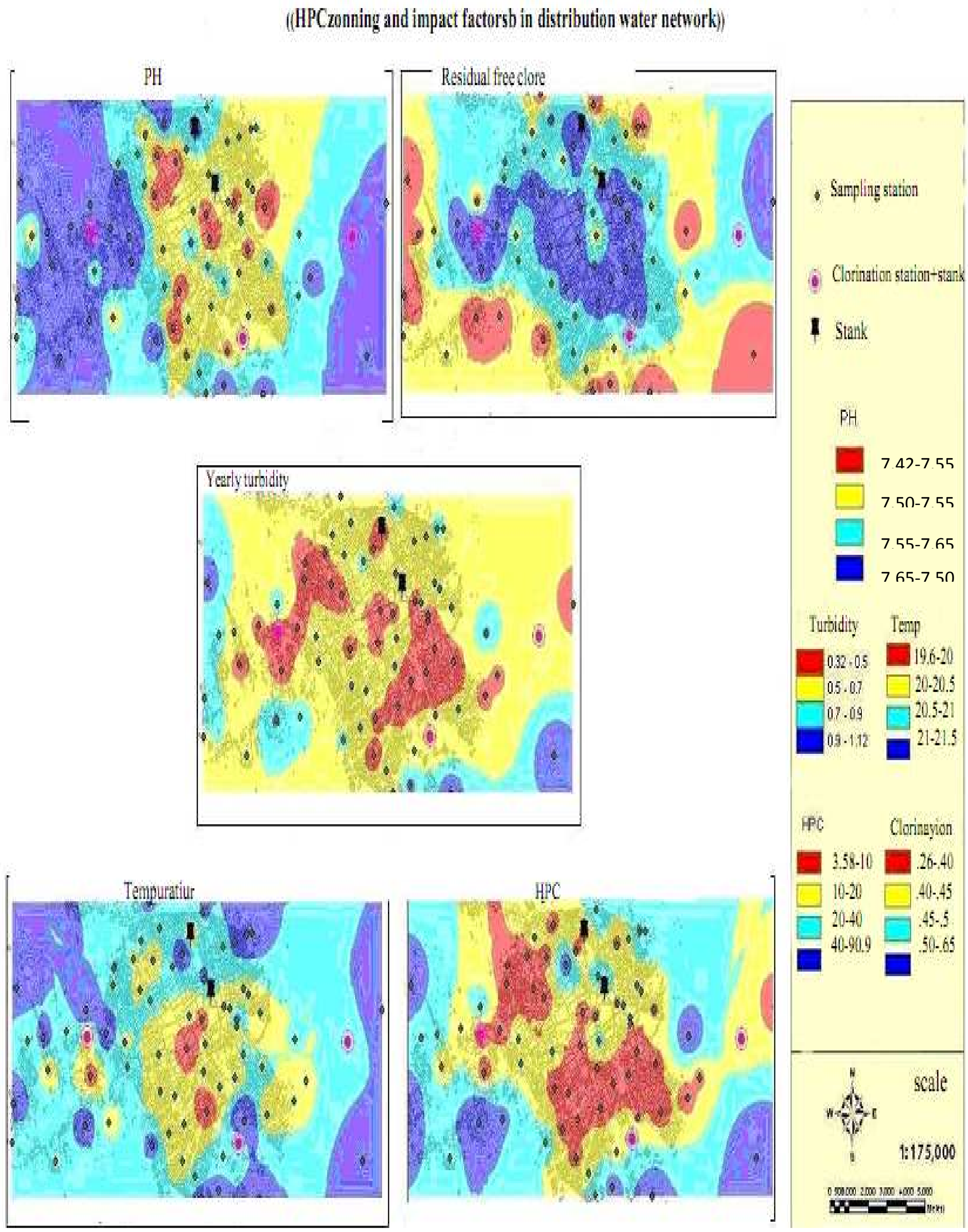

Figure5: HPC zoning and related factors in water distribution network

Amount of HPC in different point of network with an annual average of 20.32 was to range from 0 to 400 cfu/ml that in all cases lesser than drinking water microbial standard (500 cfu/ml). It's reason can be water supply from underground sources of with low microbial load and network regular washing according to guideline of Iran's Water and Wastewater Engineering Company that recommended the when the HPC is over 250cfu /ml irrigation network is to be. Also in the results %8 of samples more than 250cfu /ml exist. Monthly and seasonal average variations trend showed that HPC in June and in July and September had the highest value. In research conducted in Quebec [21]. HPC in the summer had the highest rate which main cause of that presented as pollution and increased entry of contaminated on the network to create negative pressure caused by water at low pressure which cut off the network. This can be separate on wall biofilms of pipe and release in to water and pollute the network. Meanwhile, high temperatures have direct effect on the growth of micro activities. Results in term of HPC with the results of research conducted at Isfahan (Dobaradaran, 2006), Ravel pendi of Pakistan (ShaukatFarooq, 2008 [20]), Semnan

(NouriSepehr, 2006 [4]), Mehdishahr (Mahmodian, 2005 [1]), Kermanshah (pirsaheb, 2006 [3]) Babolsar (Falah, 2010 [5]) have been significantly consonant. But in similar results of Tabriz (mosafery, 2009[2]), New Orleans (Gina M, 2006 [11]), Tuxan (IL Pepper, 2004), Ahvaz (Rabiie, 2004), and Quebec (Alex F, 2009 [21]) in some cases the amount of HPC has been higher than standard, that main causes of them was seen to network high and slowing flow, defects network and growth biofilms, home plumbing system failure, turbidity increasing, and reduce chlorine remaining at the end of the network consecutively. In all cases, obtained the WHO guidelines for the maximum 5NTU. But %6.3 of samples is higher than EPA standards (1NTU).Turbidity in summer had significant difference with other seasons. According to correlation analysis there was a direct relationship between HPC and turbidity index, that cause can be bacteria protection against the disinfection by turbidity suspended solids. We're not significant deference between pH and other parameters ($P_{value}< 0.05$). Between temperature and HPC was a direct relationship and with residual free chloric was negative relationship due to effect of temperature on microbial growth, meanwhile high temperatures accelerate removal of residual chlorine in the water. Comparison Index HPC in reservoirs and distribution networks differ significantly However no increases beyond the standard level, but indicating the microbial quality of distribution network was decreased so the potentially there is the threat for quality of water, that causes con be corrosion in some parts of the system of blind spots on the network, lack of proper chlorination provide initial free chlorine remains in all parts of the network.

CONCLUSION

With regard to lengthening of Kerman city network and negative pressure due to changes in flow rate, may be potentially contamination so regular monitoring of parameters is necessary.

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