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RESEARCH ARTICLE

Performance evaluation and siting index of the stabilization ponds based on environmental parameters: a case study in Iran

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Abstract
Stabilization ponds are open pools that remove total suspended solids, organic matters, microbial and pathogenic agents using physical, chemical, and biological processes. If the stabilization ponds are not well designed, they can produce odors, breed many insects, increase suspended solids concentration in the effluent and pollute groundwater. Consideration of environmental factors is critical for operation and maintenance. In this study, first, information on wastewater treatment plants and meteorological parameters were collected, and simultaneously, specialists were selected to score the effect of environmental factors on stabilization pond efficiency. A geographic information system was used to sit for suitable locations for stabilization ponds. The results showed that 23.6 % of Iran's treatment plants are stabilization ponds, which based on climate, evaporation, sunny hours, ice days, wind speed, and temperature parameters, 33.33 %, 37.3 %, 14 %, 50 %, 64 and 26 % of the stabilization ponds have obtained good points, respectively. The results also showed that 50 % of the stabilization ponds obtained an acceptable score considering all environmental parameters' simultaneous effect. A preliminary study based on considering all the environmental parameters showed that the central and southern regions are the best areas for establishing waste stabilization ponds; in contrast, northern and northeastern regions can have high operation and maintenance costs with lower efficiency. This study has shown that setup and design of the new waste stabilization ponds in Iran need to take into account by considering environmental factors because these factors have the main effect on algae growth which are one of main biological treatment.

Keywords Stabilization pond · Environmental factors · Siting · Iran · Wastewater

Introduction

It is estimated that until 2050, 52 % of the world's population, especially in arid regions have a serious problem which that is water shortage [1]. Among different water sources, the reuse of treated wastewater for irrigation and industrial needs can meet a significant part of these needs [2]. The wastewater treatment system can remove contaminants such as pathogens, organic matter, and microbial to be effective [3]. The nature of the wastewater entering the wastewater treatment plant and the expected use and quality of the effluent significantly impact the treatment system's choice [4]. The equipment and type of treatment system can be selected [5]. In developing countries, the biological wastewater treatment systems such as wastewater stabilization ponds (WSPs) are used [6, 7].

WSPs are open pools that remove pathogens, organic and microbial materials with physical and biological processes [8]. WSPs are used to treat domestic, industrial, and agricultural wastewater based on low technology and construction costs;

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this process has been widely used. 50 and 20 % of the wastewater treatment system in the United States and France are WSPs [9, 10]. In other parts of the world, such as Germany and sub-Saharan Africa, these systems are used as one of the most popular wastewater treatment systems, especially for small communities [10, 11]. Stabilization ponds can remove more than 60 % of biochemical oxygen demand (BOD). the anaerobic and facultative type is mostly used to remove BOD and aerobic types using for remove pathogens [12]. If the stabilization ponds are not well-managed and designed, they can produce odors, breed many insects, increase suspended solids concentration in the effluent and pollute groundwater [13]. There are several guidelines for designing stabilization ponds [9, 14]. Nowadays, a microbial index such as total coliforms, enterococci, F-RNA phages, and somatic cells are used to show WSPs efficiency, which environmental parameters affect these indexes directly [15, 16].

More water access can affect progressive algae and microorganism's growth which contribute to treatment. Water access depends on various environmental parameters [17, 18]. Evaporation is one environmental parameter which can affect the water access in ponds. In arid areas having very high temperature and water vapor pressure, evaporation is increased. Evaporation can increase the electrical conductivity (EC) and total suspended solids (TSS) of the effluent which is a negative factor [19]. Also, evaporation can reduce hydraulic retention time in ponds [20]. Because of reduced water access of algae, evaporation has a negative effect on the lifetime of algae and a consequence to algae's gradual death [21]. It is worthwhile to consider that low-temperature increases the possibility of the pond's surface freezing during the cold seasons, which causes the death of algae, reduced photosynthesis, and thus reduced efficiency. So, evaporation and icy climate should be considered on a sensible range so moderate evaporation and icy days can positively affect the efficiency of ponds regardless of the effect of other environmental factors [22]. Temperature might be a more important environmental factor due to its substantial influence on biological processes [23]. The temperature effect is critical in winter with low temperature and low hydraulic retention time (HRT) inducing less BOD removal as compared to hot summer and higher HRT [24, 25]. Attention should be paied that in stabilization ponds design, operator considers the worst temperature condition, and it is usually recommended to consider the average temperature in the coldest season as the temperature criterion in the design [26]. Sunlight has a critical role in pond's function; the longer the ultra-violate (UV) radiation time can has the higher inactivation rate [27, 28]. The disinfection mechanism depends on the pond's depth, which is directly relevant to the penetration of sunlight into the pond's depth [29–31]. Also, sunlight can increase ambient temperature and photosynthesis thereby enhancing organic pollutants removal efficiency. An area with higher sunny time provides more algal growth through increase of photosynthesis leading to improving of biological treatment [32, 33]. Another environmental parameter that should be addressed is dissolved oxygen which can be variable based on the elevation of the site from free water's surface. According to the literature, higher elevation from mean sea level results in higher concentration of dissolved oxygen which can increase WSP efficiency directly [34]. The wind speed is another parameter that should be considered in the design of WSP because it can create turbulence in the stabilization ponds so that the contents inside the ponds, inlet sewage, and microorganisms are pleasingly uniform [35]. This turbulence assists the transfer of oxygen from the upper to the lower layers and it is crucial that the speed of wind is in a sensible value [36]. In vast countries with variable climate conditions, consideration of environmental and economic parameters can help in the useful exploitation of WSP in the long term [37].

Although Iran has a variety of climates, it is located in one of the araid regions on earth with around 60 % of its area in araid regions with water shortage as a major concern [38]. Wastewater treatment can compensate the lack of water resources [39]. Considering the type of treatment system, it is essential in that system's efficiency by considering financial, technical, and environmental parameters [40]. WSP does not need mechanical equipment, so it is good for low-income countries with a suitable climate. However, consideration of environmental factors is critical because without attention to these parameters, the quality of effluent will be variable, and farmers and other consumers cannot trust to use it. This study was conducted to investigate the design criteria of stabilization ponds in different parts of Iran and investigate their correct placement in different regions by considering different environmental parameters. This is the first study that investigate the establishment of stabilization ponds with the principles and criteria for designing stabilization ponds in Iran and can help to wastewater company managers to exploit WSPs in suitable location based on environmental parameters.

Material and method

Study area description

Iran is located in the Middle East with a geographical position of 35°41′ N and 51°25′ E located in an arid region with low rainfall (Fig. 1). The temperature difference in winter and summer in some parts of Iran reaches 50°C. The amount of rainfall in some northern parts reaches more than 2000 mm, and in some dry places, about 15 mm of cumulative rainfall per year has been reported. Iran and other Middle Eastern countries are most affected by climate change due to their geographical location. Iran is the 17th largest country in the world, with an area of 1,648,195 km^2. Iran's population is

80 million, with a growth rate of 1.2 %, and 65 % of the population living in urban areas [1, 41, 42].

Data collection

Information about wastewater treatment plants throughout Iran, including the type of wastewater treatment system used, wastewater treatment capacity, incoming wastewater discharge, covered population, and geographical information of the treatment plant location, was obtained from the National Water and Sewerage Organization. At the same time, meteorological information of all cities in Iran in meteorological stations was received from the Meteorological Organization Statistics Center for the period 2015–2020, which included rainfall, type of climate, wind speed, evaporation rate, and number of frost days, total number of sunny hours, temperature, and the average annual height, the latter of which was above sea level.

Data analysis

After receiving the information, using Excel software (version 2013), the daily meteorology data were converted into annual data for each station to determine the minimum, maximum, and average for each station during 2015–2020 in each of these parameters. These values included the amount of rainfall (0.625 to 2101.97 mm), type of climate (Very wet 2, Very wet 1, Semi wet, wet, Mountain, Mediterranean, Absolutely arid, Arid,), wind speed (6.37 to 32.21 m/s), evaporation rate (144.0318 to 3846.35 mm/year), number of glacial days (0 to 133 days), average annual temperature (10.90 to 27.79 ˚C), altitude (-103 to 5592 m) and total hours of sunshine (1885.9 to 3490.47 h) during the years 2015 to 2020. It was reviewed using geographic information system (GIS) v10.3.3 software.

Classification

For classification, we used a questionnaire validated by 10 specialists. The apparent validity and content of the researcher-made questionnaire were desirable (content validity index (CVI) and Content Validity Ratio (CVR), and comprehensiveness indices above 0.8). For the internal reliability of the questionnaire, Cronbach's alpha index was higher than 0.7, which was desirable. Questionnaire was completed by 50 wastewater specialists from across Iran to consider all environmental factors scoring each factor by their knowledge. Table 1. shows the mean scores given by 50 wastewater specialists. Based on expert panel suggestions, 2 strategies were considered. Strategy 1 was considered for conditions that all of the meteorological factors could affect WSP efficiency while strategy 2 was considered for conditions that evaporation and rainfall could not affect WSP efficiency.

The scores of each city's parameters in which the wastewater treatment system had stabilization ponds were collected and calculated algebraically. Using the uniform distribution in the total scores, each wastewater treatment plant's scores were considered based on a 100 and based on expert panel suggestion divided into 7 classes as in Table 2.

Mapping

At first, the points representing all 210 wastewater treatment plants were identified using GIS and Google Earth software. According to the collected information and the prepared map, the treatment plants that used the stabilization pond system for wastewater treatment were identified. After determining the location of the treatment plants, meteorological information was received from the Meteorological Office. Interpolation was entered into GIS using the inverse distance weighted (IDW) interpolation method for meteorological data such as precipitation, air temperature, evaporation rate, altitude, number of icy days, climate, and hours of sunshine and wind speed. According to the library studies, the interpolated values were classified from 0 to 10 and reclassified.

Result and discussion

Wastewater treatment plant

The results showed that within 211 wastewater treatment plants in 174 different cities of Iran, different systems such as stabilization pond in 50 treatment plants (23.6 %), extended aeration in 41 treatment plants (19.4 %), aerated lagoon process in 43 treatment plants (20.1 %), conventional activated sludge in 36 treatment plants (17.5 %) and other active activated sludge in 41 treatment plants (19.4 %) were applied (Fig. 2.). Stabilization ponds were used more than other wastewater treatment systems because they were the first wastewater systems in Iran and had low operation and maintenance costs.

This study shows that all 211 treatment plants were designed for 22,699,448 people with a specified volume of wastewater which was 5,337,359 m^3/day (Table 7 in appendix).

Stabilization pond

The results of the study, according to Fig. 3. show that most stabilization ponds are located in the center and west. Moreover, in two cold provinces of West and East Azerbaijan and Mazandaran, Gilan, Golestan, Chaharmahal-Bakhtiari, Qom, and Fars, stabilization pond was not applied. It was also found that Isfahan had the largest share allocating 20 % of its total wastewater treatment systems to WSP

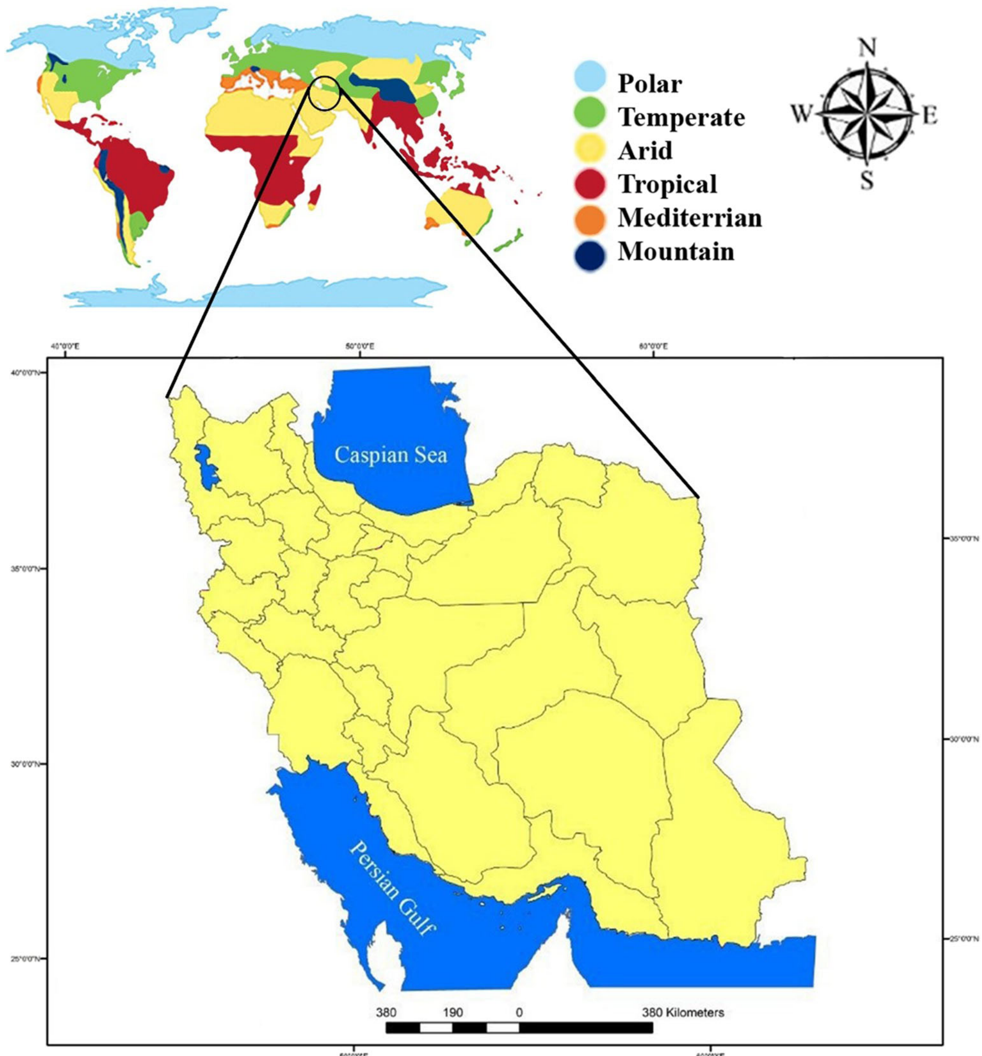

Fig. 1 Climatically description of the study area, Iran

(Fig. 3.). The results of Table 3. show that 50 stabilization ponds in Iran are designed and operated for a population equal to 4,420,475 with a specific capacity of 789,947 m^3/day (Table 8 in appendix describe operating parameters wastewater stabilization ponds based on Iranian standard).

Studies show that the most critical environmental factors affecting the performance of stabilization ponds include meteorological climates, evaporation, temperature, ice days, solar radiation time, and wind speed, which should be considered in selecting the type of treatment system [43–45]. Photosynthesis by algae plays a key role in the purification

Table 1 The weight load of each environmental parameter on the performance of stabilization ponds

parameters	Attributable factor Strategy 1	Attributable factor Strategy 2
Sunny Hours	5	5
Temperature	4	4
Evaporation	3	-
UV radiation	3	3
Icy Days	2	3
Rainfall	2	-
Climate Type	2	2
Wind Speed	1	1
Elevation	1	1

Table 2 Classification of the overall score related to environmental factors

Classification	Score from 100
Bad (B)	<60
Average (A)	61–70
Fair (F)	71–80
Good (G)	81–90
Excellent (E)	91–100

mechanisms in stabilization ponds. Photosynthesis has a direct effect on the three parameters of dissolved oxygen, pH, and chlorophyll *a*. Also, these three parameters strongly depend on weather conditions[46]. Long T.Ho et al. noted the importance of temperature and sunshine on the design of the stabilization pond and, ultimately, the treatment efficiency, which confirms the order of scoring ponds in this study [6]. A study was conducted in Rashid, Egypt, to model the effect of weather conditions on chemical and physical parameters in stabilization ponds. Accordingly, it was revealed that climatic interactions played a significant role in the behavior of bacteria, algae, and other microorganisms. Parameters such as wind speed, pressure, and dew point were directly effective in removing pollutants, and the efficiency of stabilization ponds for removing BOD, chemical oxygen demand (COD), and heavy metals was 81 %, 36 and 98 % ,receptively [47].

Climate

The results of climate-based IDW interpolation show that about 3 % (two stabilization ponds) of stabilization ponds are used in arid climates in central Iran and 23.5 % (12 cities) of stabilization ponds are located in semi-arid weather conditions. According to this study results, mountainous climatic conditions have the highest number of designed stabilization ponds with 19 stabilization ponds (37.2 %) among different climatic conditions. Also, 23.5 % of stabilization ponds are located in areas with a Mediterranean climate. The results show only one stabilization pond (1.9 %) in wet, semi-wet, and very wet weather conditions. The results also show that only 3.9 % of stabilization ponds have the highest weather conditions. Also, only 33.33 % of stabilization ponds have more than 60 % of the relevant score without considering other meteorological factors. Based on the results, 66.66 % of the stabilization ponds did not receive an acceptable score due to climate (Fig. 4.). According to technology studies, stabilization ponds for tropical and subtropical countries have higher efficiencies than other climatic regions due to favorable climatic conditions [48]. In general, the pond's climatic conditions and geographical location can help the treatment process [49].

In the all Figs there are 2 legends which the legend that locate on the left shown the ranking of the Iran map which suitable for establishing WSP based on Table 2.

This study based on all siting classification was based on GIS technique, so for Fig. 4, which have a separate classification, GIS considers 2 categories for excellent, fair, and bad.

Temperature

Ambient temperature can lead to an increase in the efficiency of removal of wastewater contaminants by stabilization ponds

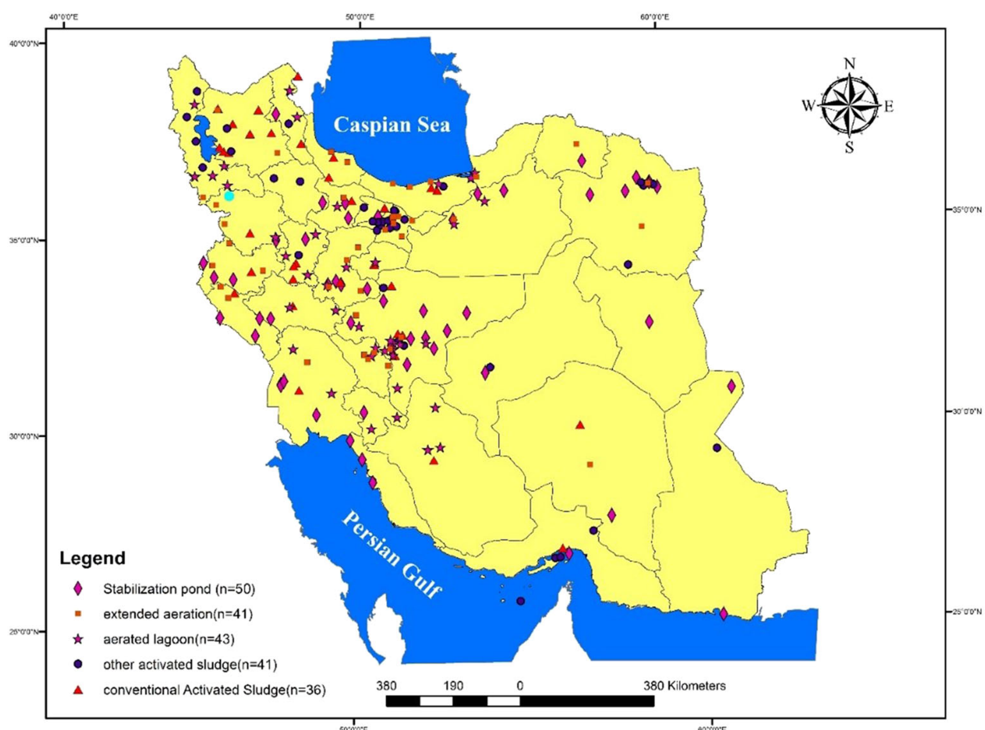

Fig. 2 Location and type of wastewater treatment system in Iran

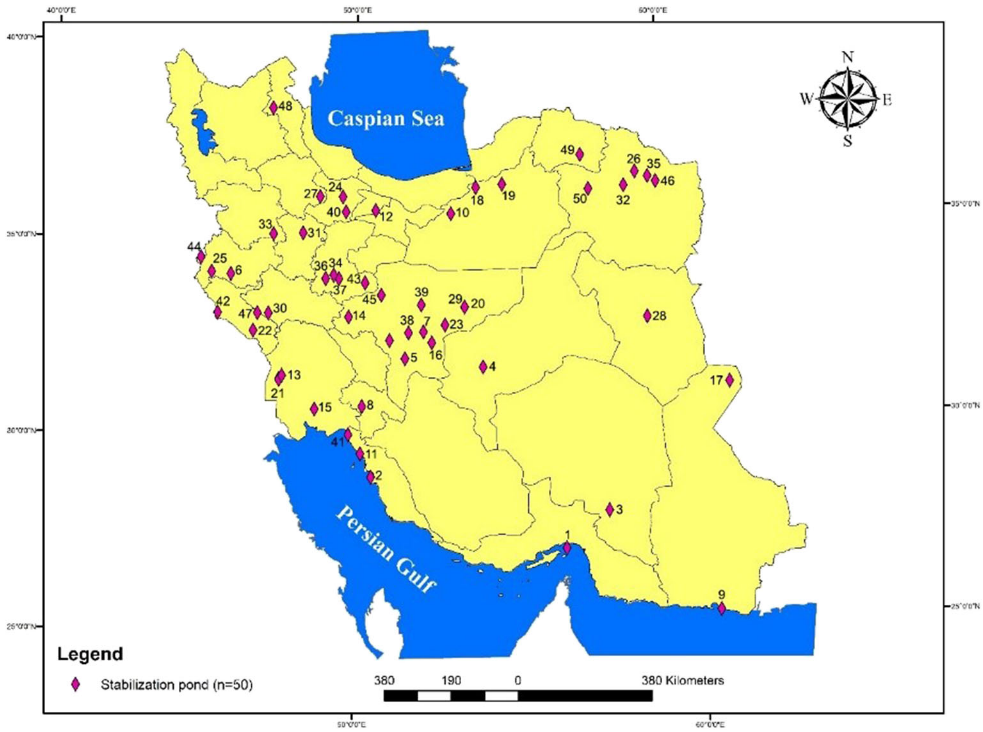

Fig. 3 Stabilization ponds locations in Iran

[50–52]. If the temperature decreases, we will face a decrease in biological activity, so that if the temperature decreases by 10˚C, the biological activity will decrease by 50 % [53, 54]. However, it should be noted that excessive increases in temperature under supersaturated conditions and more than 35˚C can have a negative effect causing algal blooms [55]. In this study, the effect of temperature on the stabilization ponds' efficiency was investigated. As shown in Fig. 5, it is indicated that 74 % of stabilization ponds are not in the right areas in terms of average temperature and less than 60 % have received the necessary scores, and 10 % of stabilization ponds are located in areas that have been able to obtain 60–90 % points in terms of average temperature, which can be acceptable. The results also show that 8 stabilization ponds, which constitute 16 % of the total stabilization ponds, have obtained the quorum of excellent scores, and these ponds have gained 90–100 % of the scores in terms of average temperature. Long et al. investigated the effect of meteorological conditions on the performance of high-altitude stabilization ponds in Ecuador, indicating that increasing altitude and consequently lowering the temperature could reduce the growth rate of microorganisms [56]. Also, the results of a study in Canada, which aimed to investigate the role of algae in the elimination and inactivation of pathogenic microorganisms (Escherichia coli, coliforms, and enterococci) in the wastewater treatment system based on stabilization ponds, showed that algae at high temperatures (20˚C) compared to low temperatures (4˚C) could effectively remove pathogens. Hence, temperature plays a crucial role in removing pathogens in stabilization ponds [57]. According to these results, in the southern, southeastern, and southwestern regions of Iran, where the temperature is high, the construction of wastewater treatment plants based on stabilization pond systems may be appropriate.

Mozaheb et al. evaluated the performance of stabilization ponds in municipal wastewater treatment in Yazd, The effluents of anaerobic stabilization pond as well as primary and secondary optional stabilization ponds were sampled to determine BOD_5, COD, SS, and fecal coliform. The concentrations of BOD_5, COD and TSS, in the final effluent were 100, 207 and 78 mg/L, respectively, and for fecal coliform it was 2400/100 CFU/mL. According to these results, the concentration of TSS in the final output follows Iranian standards for wastewater reuse in agriculture, but the final concentrations of BOD_5 and COD in the final output are too much and cannot be reused in agricultural lands [58]. However, it was revealed that the climatic condition of Yazd was favorable for the construction and efficiency of stabilization pond systems. Numerous factors can play a role in this inconsistency, including the poor design of stabilization pond systems, the amount of wastewater entering the treatment plant, and the shape of the stabilization ponds [59]. Other reasons include high evaporation and moderate to low wind speed in this area, which can have a negative impact on the efficiency of stabilization ponds. Temperature changes leads to the phenomenon of water temperature inversion in spring and autumn increasing the density and turbidity creating unpleasant odors [60]. On the other hand, using low temperatures in late autumn and early winter can effect on wastewater treatment efficiency [47].

Table 3 Determining the covered population, wastewater receiving capacity and discharge of incoming wastewater to stabilization ponds in Iran

No.	City	Population	Capacity (m^3/day)	Q(m^3/day)
1	Hormoz	2122	2250	300
2	Boushehr	177,549	90,000	38,532
3	Kahnouj	13,392	7250	3839
4	Taft	7300	1062	348
5	Chabahr	98,826	10,000	12,123
6	Isfahan	97,745	17,500	18,476
7	Deylam	346,868	100,000	55,176
8	Naein	9623	19,000	1912
9	Naein	19,539	10,601	364
10	Fooladshahr	7800	2400	1080
11	Genaveh	51,420	28,000	8330
12	Chamran	857,000	57,120	100,778
13	Zabol	4258	41,000	9280
14	Sousangerd	8037	2500	1330
15	Varzaneh	18,805	4000	3990
16	Delijan	56,734	20,000	7369
17	Khomeyn	106,956	21,000	20,622
18	Shahr Reza	280	750	182
19	Mahdishahr	29,000	30,932	1159
20	Hoveyzeh	25,389	4600	2986
21	Ardestan	9290	4688	3471
22	Damghan	10,590	9000	1898
23	Dehdasht	12,857	1700	2264
24	Arak	29,000	14,320	6307
25	Arak	18,541	6671	2901
26	Qazvin	85,454	1000	5105
27	Karaj	373,520	26,388	5748
28	Eslam Abad	181,004	10,500	16,998
29	Kaboudar Ahang	2075	300	264
30	Mohajeran	29,000	2500	2471
31	Mashhad	7185	3564	1627
32	Mashhad	175,448	20,000	15,772
33	Gilan Gharb	79,657	16,000	12,739
34	Bouin and Miandasht	79,657	16,000	12,739
35	Birjand	429,800	60,000	50,318
36	Dehloran	22,413	1600	4039
37	Mehran	51,524	5000	10,126
38	Koohpayeh	5601	760	888
39	Pol Dokhtar	6284	4000	969
40	Abhar	22,500	2361	2299
41	Neishabour	8208	7500	1632
42	Dareh Shahr	13,384	9945	2921
43	Ghasr Shirin	46,000	5585	7851
44	Golbahar	18,700	5200	3640
45	Shahrood	53,705	6600	8831
46	Bouin Zahra	250,000	25,000	25,423
47	Ghorveh	18,259	12,600	3167
48	Meshkin Shahr	50,148	13,000	7143
49	Esfarayen	50,901	8000	7121
50	Sabzevar	241,493	19,300	30,890
Total		4,000,000	789,947	568,224

Evaporation

Evaporation is one of the environmental parameters which can affect the amount of available water and also the concentration of constituents it thereby influencing the WSP efficiency. Indeed, sufficient amount of water improves the growth of microorganism and algae which in turn, can improve the treatment process [17, 18]. Results shown that in 7 regions of Iran (located in Isfahan province), there is the highest rate of evaporation which can have a negative effect on efficiency of WSPs, so by consideration evaporation data results shown that 13.7 % (7 WSPs which located in Isfahan province) of the WSPs have the lowest score. The results also show that without considering other parameters and calculating the effect of the evaporation factor, about 62.7 % of the stabilization ponds get less than 60 % of the required points and receive 37.3 % of the acceptable points. Only one area (Meshkinshahr) has received full points. In general, in areas with cold and mountainous climates, due to the decrease in temperature, evaporation has decreased and has caused these areas to get an acceptable score in evaporation parameters for the design and operation of stabilization ponds. The results show that Iran's average evaporation varies from 2.4 to 611.203 mm/day (Fig. 6). In order to reduce the rate of evaporation, the proposed depth of the ponds is 2.4 to 3.6 m [61].

Sunny hours and UV radiation

As it is well-established, sunlight can play a role in inactivating indicator organisms as well as affecting the dissolved oxygen concentration [27]. Also, the amount of sunlight to the diversity and viability of algae in stabilization ponds improves ponds' efficiency [62]. It was found that 56 % of the pond-stabilized areas scored less than 60 %. As Fig. 6 shows, the areas that received less than 60 % of the required score are in the southern, southeastern, and central Iran regions. The results show that 12 % of the stabilization ponds located in southwestern Iran, according to Fig. 7 were able to obtain 60–70 % of the points in terms of sunshine hours. The results also show that seven areas (14 %) in which stabilization ponds are located have received more than 90 %

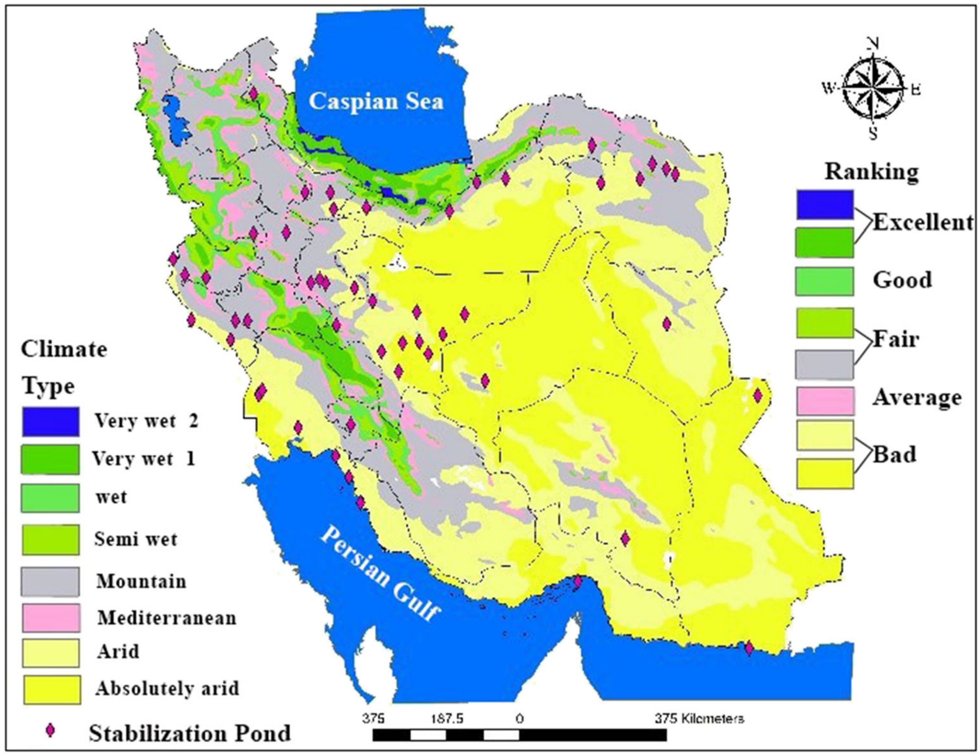

Fig. 4 Comparison of different meteorological climates with the location of stabilization ponds

points of classification. Out of these 7 regions, 4 regions, which constitute 8 % of the total stabilization ponds in Iran, have obtained 100 % points in terms of sunny hours considering that the stabilization ponds in the southern half of the country have obtained higher scores than other regions of Iran. In the anaerobic ponds, it can be pointed out that in the southern regions, the average temperature and sunny hours are higher, if the stabilization pond is properly designed. Up to 60 % BOD removal at 20 °C can be achieved, while a one-day HRT is sufficient for wastewater with a maximum BOD of

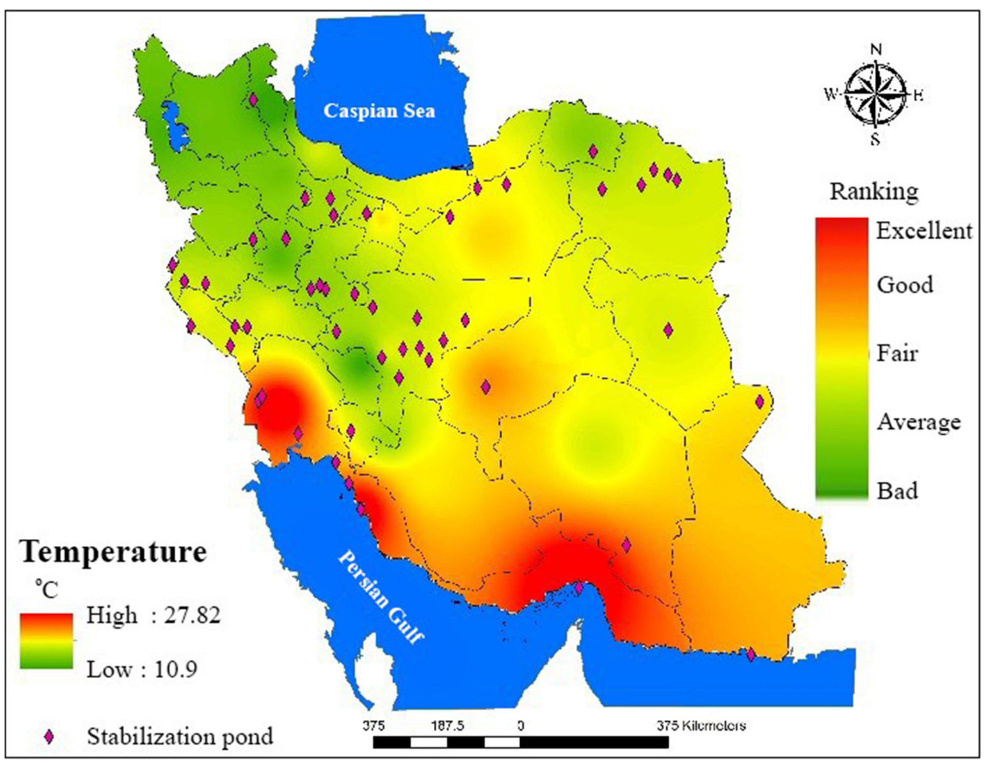

Fig. 5 Comparison of the average annual temperature in Iran with the location of stabilization ponds

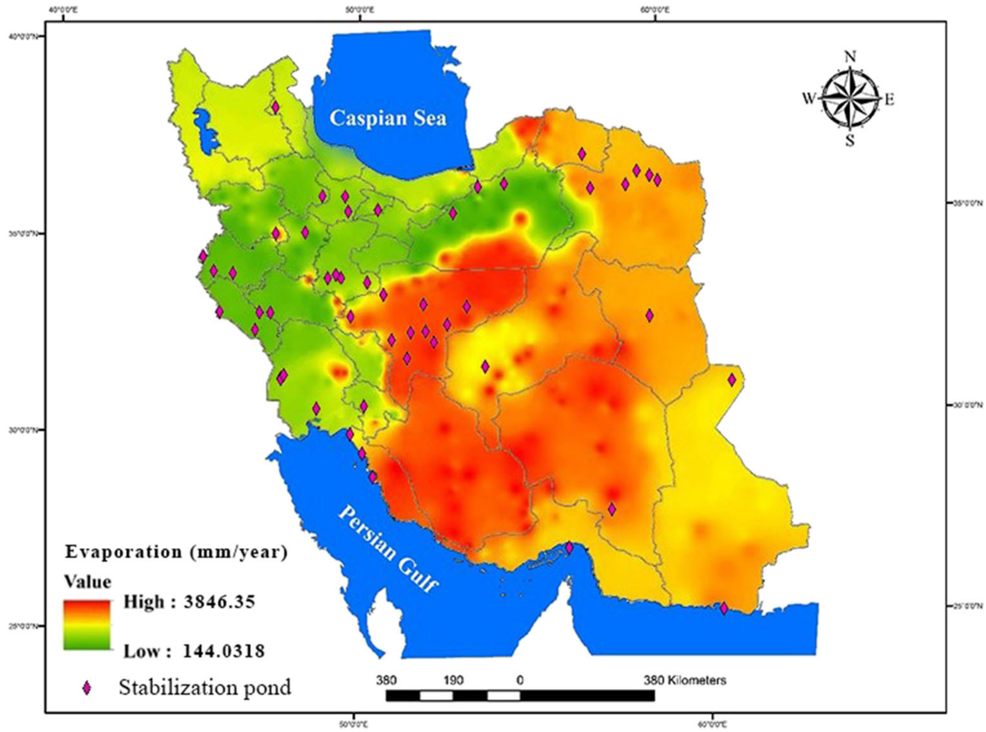

Fig. 6 Comparison of evaporation rate in millimeters in Iran with the location of stabilization ponds

300 mg/L at temperatures above 20 °C, and if the temperature falls below 15 °C, the process Digestion is also reduced [12]. This is a justification for the inefficiency of stabilization ponds in the cold western regions of the country. The importance of sunny hours is reflected as the thermal classification in the ponds which is seasonal or daily and is based on the temperature in summer and the hours of light [63]. And sunny conditions lead to the photosynthesis of anaerobes and the growth of purple and green non-sulfur bacteria [64].

In addition to the sunny hours, the amount and strength of UV radiation are essential for the disinfection process and have a lethal impact on pathogens [65].In the area with more

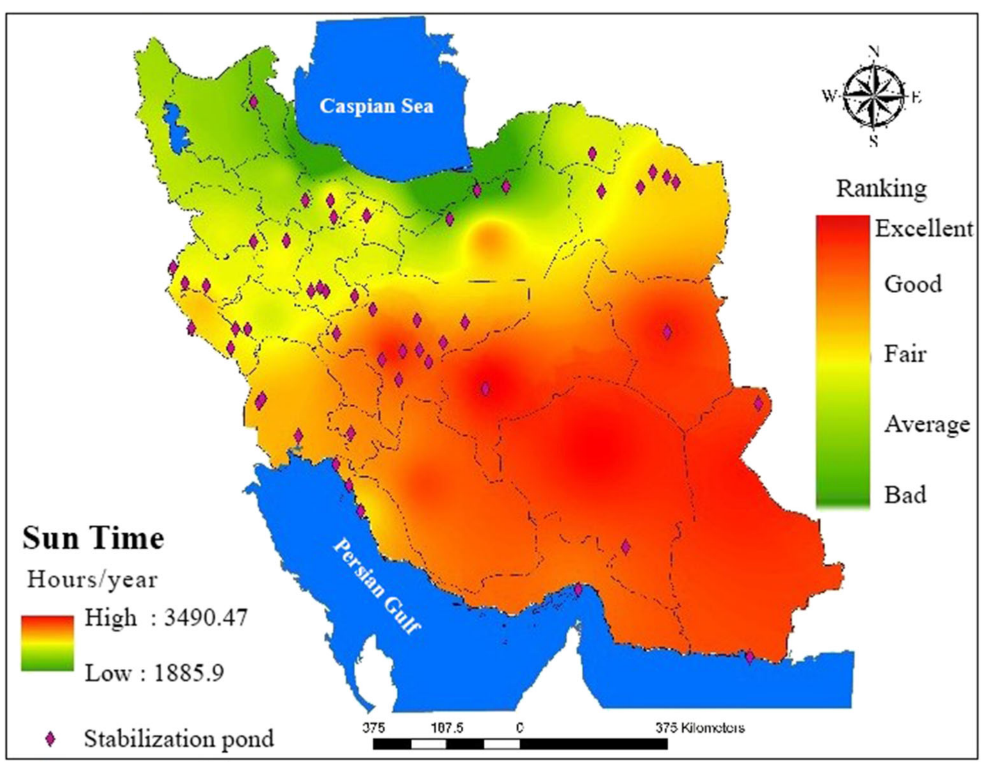

Fig. 7 Comparison of the number of sunny hours in Iran with the location of stabilization ponds

UV radiation, there is more solar disinfection so that the outlet can be observed high quality of effluent [66]. As shown in Fig. 8. 40 % of WSPs are located in areas with more than 2100 Kwhm-2 year-1 UV radiation, 34 % of WSPs are located in areas where UV radiation is between 2000 and 2100 Kwhm^{-2} year^{-1}. Results of this study showed that 22 % of WSP constructed in an area which has UV radiation power between 1700 and 1900 Kwhm^{-2} year^{-1}, 2 % WSPs has UV radiation between 1900 and 2000 Kwhm^{-2} year^{-1}, Also results indicated that 2 % of WSPs located in the area which has less than 1700 Kwhm^{-2} year^{-1} UV radiation intense. In Lei Liu et al. study investigating the effect of solar radiation on WSPs efficacy, WSPs located in areas with short UV wavelength and high UV radiation strong have more disinfection power, so these WSPs have high quality in influent [67].

Ice days

As a note mentioned in the temperature, when the water temperature was decreased, WSP had a minimum efficiency because freezing the surface of the WSP can follow the low efficiency of organic matter removal [17, 18]. As shown in Fig. 9. in 50 % of the areas where stabilization ponds are located, the icy days are to the extent that the points obtained by this number of stabilization ponds are less than 60 % of the required points. The results showed that 46 % of the stabilization ponds received 60–80 % of the points related to glacial days. Also, the results of this study indicate that 4 % of the stabilization ponds are located in southern Iran and include Bushehr and the port of Hormoz.

Wind speed

According to the considered criteria, 36 % of the stabilization ponds in terms of wind speed could not receive more than 60 % of the points. The results also show that 54 % of the areas where stabilization ponds have been installed have scored 60–90 %. This study shows that 10 % of the areas that have stabilization ponds in terms of the effect of wind speed on the efficiency of stabilization ponds have a score of more than 90 %, which indicates the excellent placement of stabilization ponds in terms of wind speed. These areas are in the west and east of the country. In the west, naturally, due to the mountainous conditions in Qorveh, Dehdasht, Buin, and Miandasht, the wind speed is suitable for the positive effect on stabilization ponds' efficiency. In this city windy days was report (about 120 days), the wind speed is suitable and has made these 5 cities receive 100 % points in terms of wind speed. According to Fig. 10, stabilization ponds in areas with higher wind speeds have good efficiency in operation [68]. In the study of Ho Long T et al., Strong winds and vast temperature differences during the day (7–20°C) increased the mixing of wastewater in ponds and thus increased the removal efficiency. Sunlight caused algae to grow and dissolved oxygen to rise. However, the overgrowth of algae depletes dissolved oxygen during the night [56]. Our study results also showed that the southern, southeastern, and southwestern regions of Iran, which have low altitude, high sunlight, temperature difference suitable for wastewater mixing, are the most suitable areas for the construction of stabilization pond systems for wastewater treatment. So the present study results are consistent with Ho Long et al. [56]. The wind is essential for the growth of algae. In the presence of wind, the thickness of algae is 20 cm, and in the absence of wind, the thickness of algae reaches 50 cm, which has an influential role in the quality of the effluent, it is noteworthy that deficiency of selected ponds can lead to inaccurate interpretation [14, 43].

Rainfall

The results show that 56 % of areas have obtained less than 60 % of the necessary scores and 38 % of stabilization ponds are in areas where 60–90 % of the necessary scores received rainfall conditions, which are often in the west and central areas. Also results indicated that 6 % of the areas where fixed ponds are located in 90–100 % of the privileges include Karaj, Dehddasht, and Islamabad West (Fig. 11.).

Table 4 shows the results of scoring stabilization ponds based on all meteorological parameters, in which each environmental parameter is scored from 1 to 10.

In Table 5 the score of each parameters was applied as strategy 1 and 2 defined in Table 1. The final score calculated based on Eq. 1 which grade is initial score of meteorological factors for each stabilization pond and weight consider based on Table 1.

$$final\ score = grade \times weight \tag{1}$$

$finalscore = grade \times weight$ Eq. 1

Table 6 shows the final score and classification of stabilization ponds of Iran based on environmental factors. For consideration of all environmental factors in this study, strategy 1 was selected; based on applying strategy 1 scores 2 stabilization ponds (4 %) which belong to Esfarayen and Sabzevar, were in bad class. About 4 % were in the Poor class, 32 % in the middle class, 20 % in the fair class, 30 % in the good class, and 10 % (Foolad Shahr, Hormoz, Taft, Kahnouj, Boushehr) in high class (Table 6). This study shows that stabilization ponds located in the southern half of Iran have a good to excellent score regarding the effect of environmental factors on the efficiency of stabilization ponds. The results also show that the whole of Hormozgan province and the southern half of Kerman province, according to the zoning done in Fig. 11 is the best province to construction and stabilization pond.

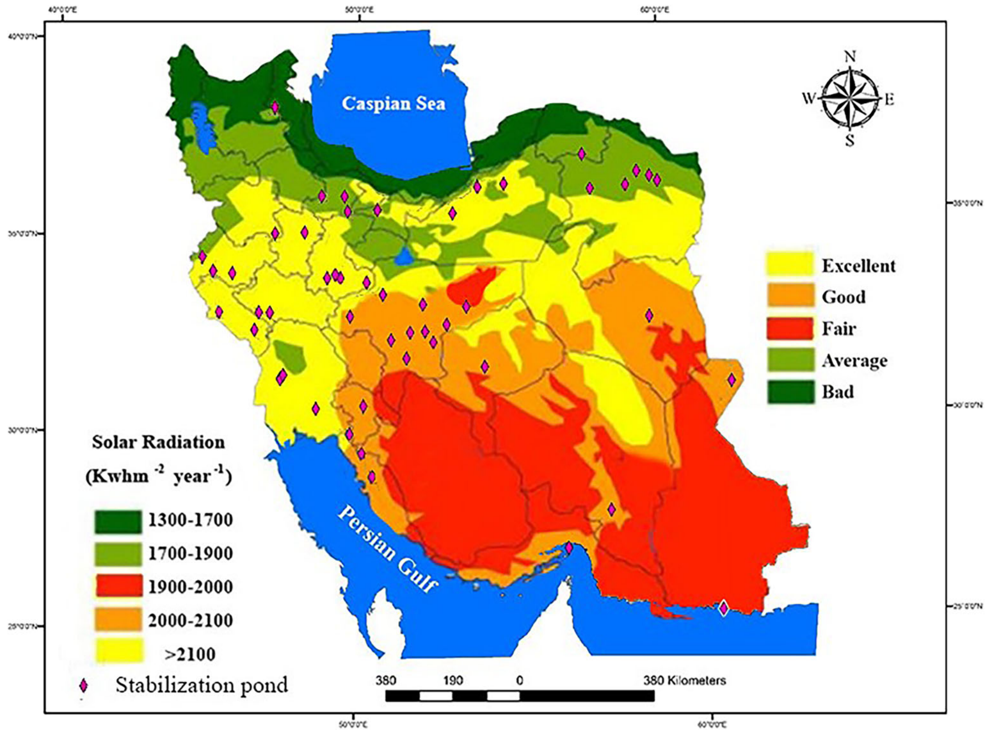

Fig. 8 Comparison of the UV radiation in Iran with the location of stabilization ponds

Based on environmental and meteorological factors in the Northern provinces (north and north-west), using the WSPs is wrong. The design and construction of stabilization ponds in these areas can negatively affect these ponds' efficiency (Fig. 11). Due to algae's presence at high temperatures, BOD removal is better, so the existence of a stabilization pond in cities with higher average temperatures can be justified, which also has a higher efficiency in treatment [56]. As shown in Table 6, cities with high average temperatures have received higher points for treatment efficiency, while in general, 74 % of Iran's stabilization ponds, despite the very high importance of the temperature factor, are not in the right place. This indicates a lack of evaluation in selecting the correct treatment system before constructing the pond. One of the

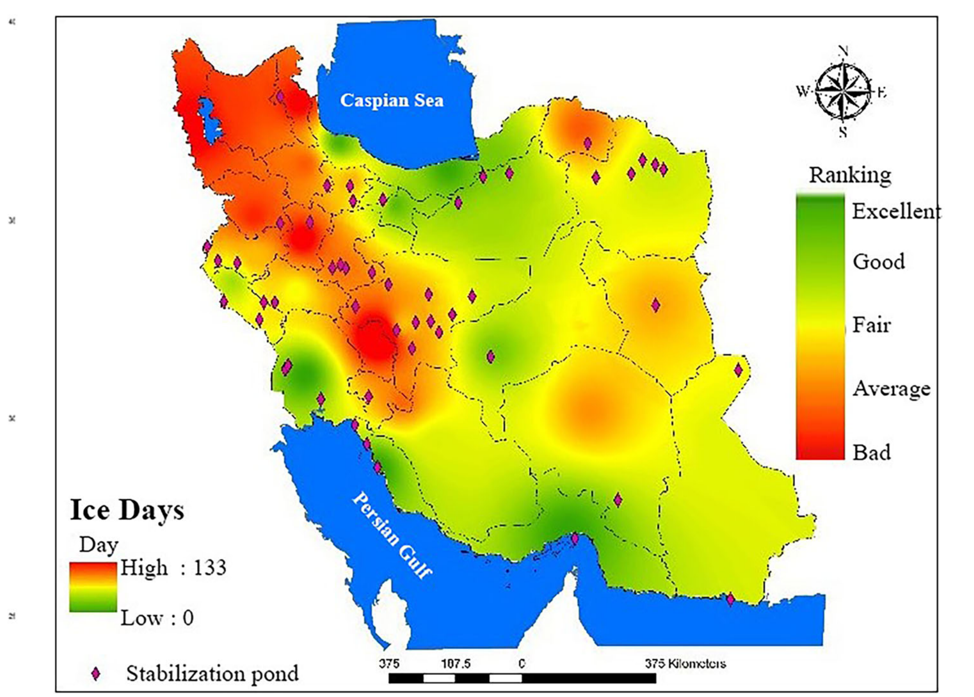

Fig. 9 Comparison of the icy days in Iran with the location of stabilization ponds

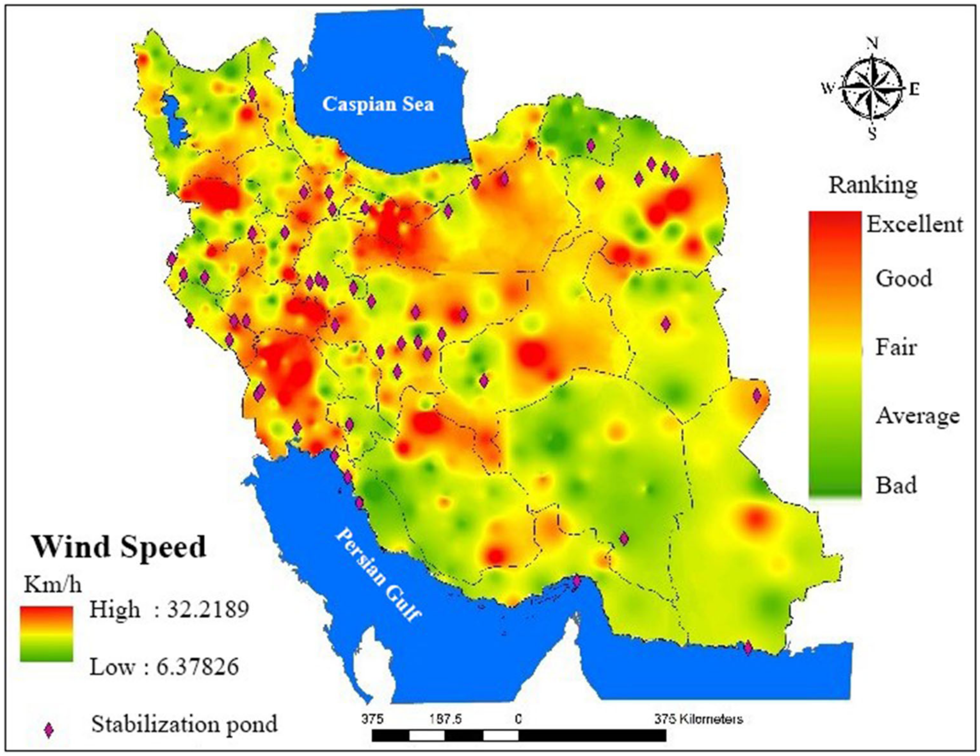

Fig. 10 Comparison of wind speed in Iran with the location of stabilization ponds

reasons for using this type of purification system, despite its incompatibility in some parts of the country, is that it is cheap and does not require advanced and unique technology and mechanical equipment. However, the maintenance and operation of this system, despite its simplicity, should be done regularly to prevent serious problems [69]. A study was conducted in Iran to investigate the reliability of stabilization ponds in the Iranian climate results shown that most WSPs located in Isfahan, Khorasan Razavi, Bushehr, Markazi, and Yazd provinces, were studied and statistically analyzed. The

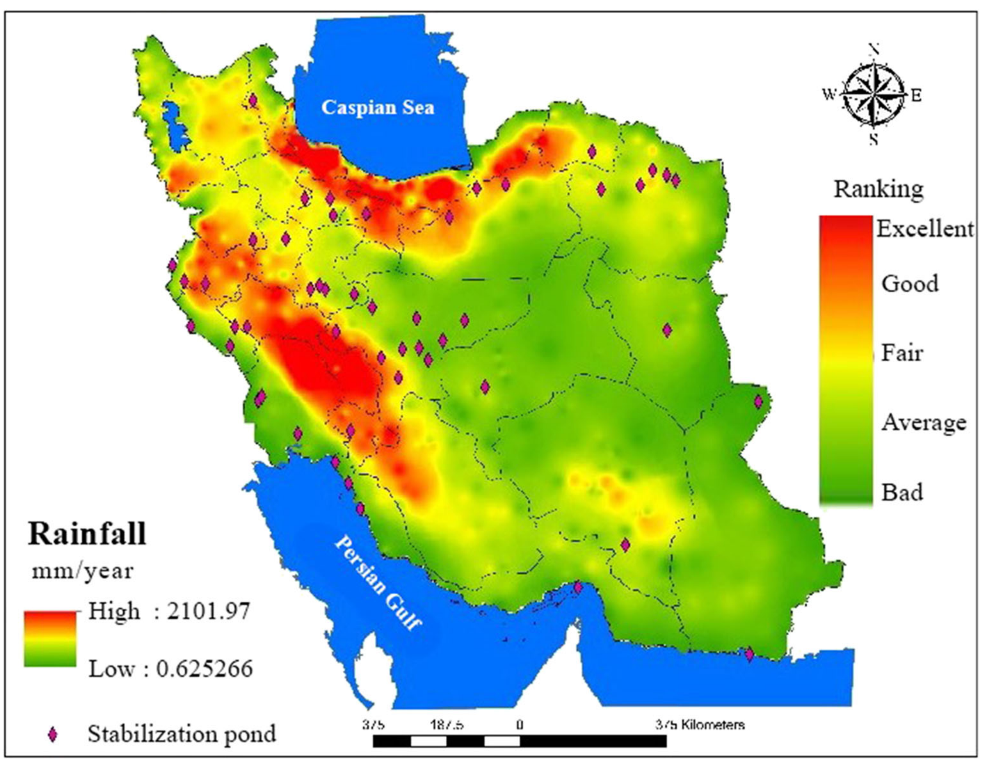

Fig. 11 Comparison of rainfall in Iran with the location of stabilization ponds

Table 4 Initial score of stabilization ponds based on meteorological factors

No.	City	Icy Days	Rainfall	Temperature	Climate	Elevation	Wind Speed	Sunny Hours	UV Radiation	Evaporation
1	Hormoz	10	2	10	10	2	7	9	4	4
2	Boushehr	10	2	10	9	1	3	10	3	3
3	Kahnouj	10	5	10	2	4	7	10	3	3
4	Taft	10	3	9	1	5	8	10	4	4
5	Chabahr	8	3	9	8	2	7	9	3	3
6	Isfahan	6	7	6	6	6	9	10	5	5
7	Deylam	9	1	8	7	1	2	9	4	4
8	Naein	7	9	7	6	5	7	9	4	4
9	Naein	7	2	7	6	5	7	9	4	4
10	Fooladshahr	7	2	8	6	6	7	9	2	2
11	Genaveh	8	2	9	10	1	5	7	3	3
12	Chamran	8	10	9	2	1	4	7	8	8
13	Zabol	8	1	8	1	2	10	9	4	4
14	Sousangerd	8	2	10	2	1	5	7	6	6
15	Varzaneh	6	8	7	6	5	6	8	4	4
16	Delijan	7	9	5	4	6	2	7	8	8
17	Khomeyn	7	7	5	4	6	2	7	8	8
18	Shahr Reza	7	2	6	6	7	7	8	1	1
19	Mahdishahr	8	8	7	5	7	7	4	6	6
20	Hoveyzeh	8	6	9	2	3	8	6	3	3
21	Ardestan	7	1	7	4	4	7	7	3	3
22	Damghan	8	7	7	4	7	8	4	6	6
23	Dehdasht	7	2	5	4	2	2	7	8	8
24	Arak	7	7	5	4	6	2	6	8	8
25	Arak	7	3	5	4	6	2	6	8	8
26	Qazvin	7	5	4	5	4	6	5	9	9
27	Karaj	5	7	5	5	5	7	5	8	8
28	Eslam Abad	5	7	4	7	5	8	5	6	6
29	Kaboudar Ahang	4	8	4	5	4	5	5	9	9
30	Mohajeran	4	6	5	4	6	8	6	5	5
31	Mashhad	6	6	5	4	5	7	6	4	4
32	Mashhad	6	2	5	4	5	7	6	4	4
33	Gilan Gharb	7	5	4	5	4	7	5	6	6
34	Bouin and Miandasht	4	6	3	6	10	10	6	4	4
35	Birjand	6	1	4	2	5	8	8	2	2
36	Dehloran	6	4	5	4	1	8	4	8	8
37	Mehran	6	7	5	2	1	8	6	6	6
38	Koohpayeh	6	3	4	6	6	3	8	1	1
39	Pol Dokhtar	5	6	5	4	1	8	4	8	8
40	Abhar	6	3	3	4	7	8	4	8	8
41	Neishabour	6	1	5	4	4	5	6	4	4
42	Dareh Shahr	6	2	4	4	5	10	5	5	5
43	Ghasr Shirin	5	3	5	4	1	8	4	8	8
44	Golbahar	6	8	5	4	5	8	5	4	4
45	Shahrood	7	4	6	2	4	9	4	5	5
46	Bouin Zahra	5	6	2	2	5	7	3	8	8
47	Ghorveh	2	2	3	6	6	10	3	4	4
48	Meshkin Shahr	1	6	1	3	5	4	1	10	10
49	Esfarayen	3	5	2	2	5	4	2	4	4
50	Sabzevar	5	5	2	2	3	3	2	3	3

results showed that the mean concentration of BOD, COD, TSS in the effluent is according to Iranian standards so is suitable for discharge in surface water and reuse [70]. Our study's results also showed that the climatic conditions of Khuzestan, Yazd, Bushehr, and some southeastern parts of the central provinces are an acceptable and good site for WSPs construction. This study shows that strategy 1 and strategy 2 cannot affect the classification of the best to the worst situation of wastewater stabilization pond. So, to consider the influence of all parameters, strategy 1 was selected.

A study was conducted in Birjand to evaluate the performance of stabilization ponds which showed that the average concentration of BOD_5, COD, suspended solids (SS) was 109, 241, 74 mg/L, respectively. Likewise, the turbidity was 138 NTU. Because the concentration of the mentioned parameters was more than the allowable limit of the Environmental Protection Agency of Iran, the pond stabilization system did

Table 5 The final score of environmental factors for stabilization pond which located across Iran by applying weigh of each environmental factor

City	Icy Days	Rainfall	Temperature	Climate	Elevation	Wind Speed	Sunny Hours	UV Radiation	Evaporation
Boushehr	20	4	40	20	2	7	45	12	12
Hormoz	20	4	40	18	1	3	50	9	9
Kahnouj	20	10	40	4	4	7	50	9	9
Taft	20	6	36	2	5	8	50	12	12
Isfahan	16	6	36	16	2	7	45	9	9
Fooladshahr	12	14	24	12	6	9	50	15	15
Chabahr	18	2	32	14	1	2	45	12	12
Dehdasht	14	18	28	12	5	7	45	12	12
Genaveh	14	4	28	12	5	7	45	12	12
Sousangerd	14	4	32	12	6	7	45	6	6
Chamran	16	4	36	20	1	5	35	9	9
Eslam Abad	16	20	36	4	1	4	35	24	24
Zabol	16	2	40	4	1	5	35	18	18
Naein	16	4	32	2	2	10	45	12	12
Mahdishahr	12	16	28	12	5	6	40	12	12
Karaj	14	18	20	8	6	2	35	24	24
Shahr Reza	14	14	20	8	6	2	35	24	24
Varzaneh	14	4	24	12	7	7	40	3	3
Bouin and Miandasht	16	16	28	10	7	7	20	18	18
Damghan	16	12	36	4	3	8	30	9	9
Hoveyzeh	14	2	20	8	2	2	35	24	24
Shahrood	16	14	28	8	7	8	20	18	18
Naein	14	4	28	8	4	7	35	9	9
Dareh Shahr	14	14	20	8	6	2	30	24	24
Birjand	14	6	20	8	6	2	30	24	24
Golbahar	14	10	16	10	4	6	25	27	27
Gilan Gharb	10	14	20	10	5	7	25	24	24
Qazvin	10	14	16	14	5	8	25	18	18
Abhar	8	16	16	10	4	5	25	27	27
Kaboudar Ahang	8	12	20	8	6	8	30	15	15
Arak	8	12	12	12	10	10	30	12	12
Koohpayeh	14	4	16	10	4	7	25	18	18
Arak	12	10	16	4	5	8	40	9	9
Neishabour	12	12	20	8	5	7	30	12	12
Deylam	12	2	20	8	5	7	30	12	12
Mashhad	12	8	20	4	1	8	30	18	18
Pol Dokhtar	12	14	20	8	1	8	20	24	24
Khomeyn	12	6	16	12	6	3	40	3	3
Mohajeran	12	12	16	8	5	10	25	15	15
Ardestan	12	6	12	8	7	8	20	24	24
Ghasr Shirin	10	2	20	8	1	8	20	24	24
Mehran	12	4	20	8	4	5	30	12	12
Delijan	10	6	20	8	1	8	20	24	24
Ghorveh	14	16	24	4	4	9	20	15	15
Mashhad	12	8	20	8	5	8	25	12	12
Bouin Zahra	10	12	8	4	5	7	15	24	24
Dehloran	4	4	12	12	6	10	15	12	12
Meshkin Shahr	2	12	4	6	5	4	5	30	30
Esfarayen	6	10	8	4	5	4	10	12	12
Sabzevar	10	10	8	4	3	3	10	9	9

not have the appropriate efficiency in removing pollutants [71]. As Fig. 11. shows, Birjand city has a 60 to 70 of the simultaneous effect of all meteorological parameters getting the average score in terms of classification. Anaerobic ponds, despite the odor problem, can be used in cities that do not have much land available for pool development since they occupy low space,, while the odor problem can be controlled to some extent with proper design [12]. Southern provinces such as Bushehr and Hormozgan with a small area and suitable conditions for anaerobic pond construction can be justified and have received high scores for stabilization ponds. Based on strategy 1, the best area for using wastewater stabilization pond in Iran is indicated in Fig. 12.

Based on Fig. 13. center, south, and east-south of Iran are the best areas for WSP by considering environmental parameters. The results of Farzadkia et al. study was confirmed that arid area which located center and south of Iran was

Table 6 The final score and classification for stabilization ponds of Iran based on environmental factors

City	Strategy 1	Strategy 1 from 100	Classification of strategy 1	Rank 1	Strategy 2	Strategy 2 from 100	Classification of strategy 2	Rank 2
Boushehr	162	100.00	E	1	146	100.00	E	1
Hormoz	154	97.887	E	2	141	96.58	E	2
Kahnouj	153	92.254	E	3	134	91.78	E	3
Taft	151	92.254	E	4	133	91.10	E	4
Isfahan	146	88.732	G	5	131	89.73	G	5
Fooladshahr	157	87.324	G	6	128	87.67	G	6
Chabahr	138	86.620	G	7	124	84.93	G	7
Dehdasht	153	83.803	G	8	123	84.25	G	8
Genaveh	139	83.803	G	9	123	84.25	G	9
Sousangerd	132	83.099	G	10	122	83.56	G	10
Chamran	135	82.394	G	11	122	83.56	G	11
Eslam Abad	164	81.690	G	12	120	82.19	G	12
Zabol	139	80.986	F	13	119	81.51	G	13
Naein	135	80.282	F	14	119	81.51	G	14
Mahdishahr	143	78.169	F	15	115	78.77	F	15
Karaj	151	78.169	F	16	109	74.66	F	16
Shahr Reza	147	78.169	F	17	109	74.66	F	17
Varzaneh	114	78.169	F	18	107	73.29	F	18
Bouin And Miandasht	140	77.465	F	19	106	72.60	F	19
Damghan	127	75.352	F	20	106	72.60	F	20
Hoveyzeh	131	75.352	F	21	105	71.92	F	21
Shahrood	137	73.239	F	22	105	71.92	F	22
Naein	118	71.127	F	23	105	71.92	F	23
Dareh Shahr	142	70.423	A	24	104	71.23	F	24
Birjand	134	70.423	A	25	104	71.23	F	25
Golbahar	139	69.718	A	26	102	69.86	A	26
Gilan Gharb	139	69.014	A	27	101	69.18	A	27
Qazvin	128	69.014	A	28	96	65.75	A	28
Abhar	138	67.606	A	29	95	65.07	A	29
Kaboudar Ahang	122	67.606	A	30	95	65.07	A	30
Arak	118	67.606	A	31	94	64.38	A	31
Koohpayeh	116	67.606	A	32	94	64.38	A	32
Arak	113	66.197	A	33	94	64.38	A	33
Neishabour	118	65.493	A	34	94	64.38	A	34
Deylam	108	64.789	A	35	94	64.38	A	35
Mashhad	119	64.085	A	36	93	63.70	A	36
Pol Dokhtar	131	63.380	A	37	93	63.70	A	37
Khomeyn	101	63.380	A	38	92	63.01	A	38
Mohajeran	118	62.676	A	39	91	62.33	A	39
Ardestan	121	62.676	A	40	91	62.33	A	40
Ghasr Shirin	117	62.676	A	41	91	62.33	A	41
Mehran	107	61.972	A	42	91	62.33	A	42
Delijan	121	61.972	A	43	91	62.33	A	43
Ghorveh	121	61.268	A	44	90	61.64	A	44
Mashhad	110	61.268	A	45	90	61.64	A	45
Bouin Zahra	109	59.859	B	46	73	50.00	B	46
Dehloran	87	57.746	B	47	71	48.63	B	47
Meshkin Shahr	98	47.887	B	48	56	38.36	B	48
Esfarayen	71	41.549	B	49	49	33.56	B	49
Sabzevar	66	40.141	B	50	47	32.19	B	50

appropriate to establish the WSPs instead of other wastewater systems which are expensive in construction and operation [72].

Conclusion

The results depicted that sunny hours and temperature had the most effect on stabilization efficiency. It was expected that WSPs distribution was in the areas which these parameters were maximum, but siting the WSPs showed that they were located on the west of Iran having moderate sunny time and temperature. A preliminary study considering all the environmental parameters revealed that the central and southern regions were the best areas for establishing WSP. Furthermore, northern, northeastern, and western regions can have high operation and maintenance costs. The stabilization ponds in

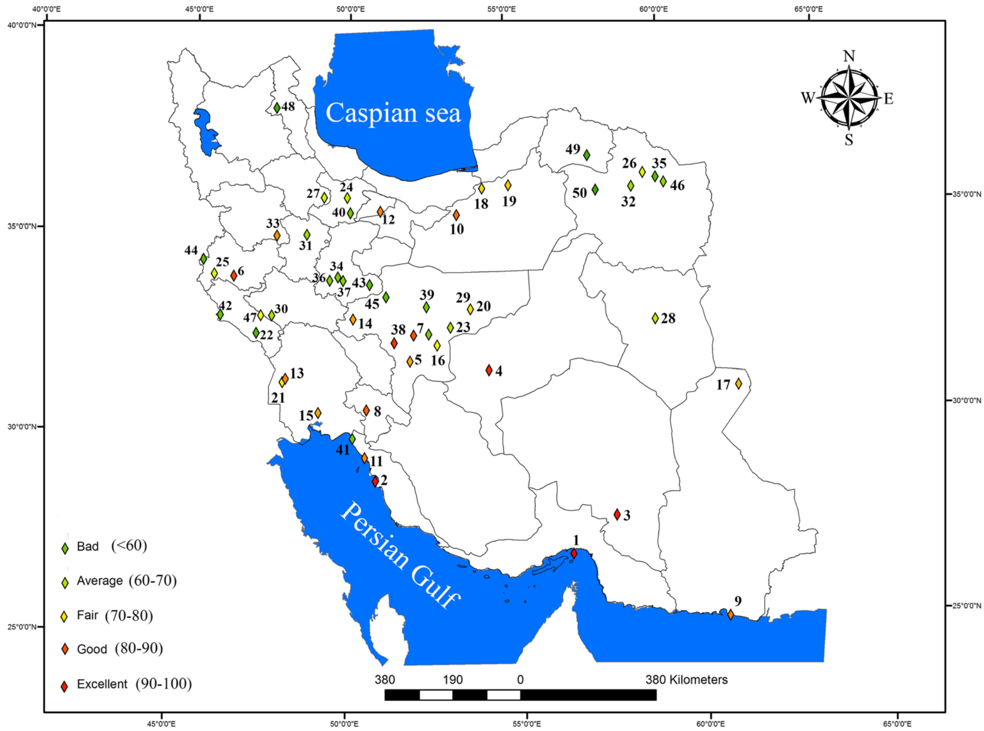

Fig. 12 The final score of stabilization ponds based on environmental factors

these areas, especially in Sabzevar and Meshkinshahr, do not have proper treatment efficiency scores, and utilizing advances in wastewater treatment sounds to be a good choice. Also, due to Iran's vastness and the variety of meteorological parameters in Iran, it is expected that in the northern, north-eastern, western, and northwestern regions, advanced sewage systems would be better options to ensure the quality of the effluent for reuse. This study has shown that the application and design of the new WSP in Iran needs to be revised by considering environmental factors because these factors have the main effect on algae growth, which plays an important role in biological treatment.

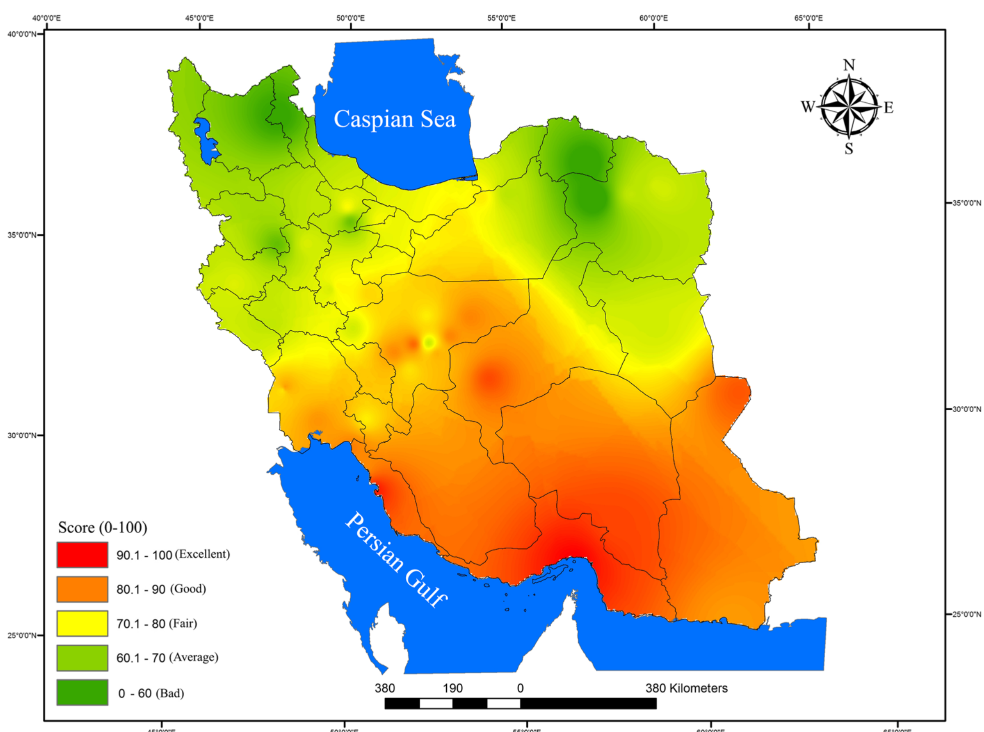

Fig. 13 Siting suitable locations for the construction of stabilization ponds based on environmental factors

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Declarations

Conflict of Interest The authors declare they have no actual or potential competing financial interests.

Appendix

Table 7 Covered population, capacity of sewage and discharge sewage input to Iran's wastewater treatment plant

City	Q(m^3/day)	Capacity (m^3/day)	Population
Ahar	21213	21600	89989
Bostan Abad	3098	7650	18247
Bonab	11126	43200	64218
Tabriz	147761	129600	1215022
Jolfa	2810	2400	4235
Sarab	7163	2142	39679
Sahand	12440	14000	133504
Ajab Shir	4868	6300	31009
Maragheh	20195	21120	80697
	19804	21120	80698
Marand	19929	15000	77976
Mianeh	25984	26000	75869
Urmiyeh	76302	80000	577183
Sardasht	2648	15482	40967
Boukan	29977	52000	196633
Mahabad	32635	40320	170257
Piranshahr	16210	11400	88597
Miandoab	19175	21000	85044
Naghadeh	15095	23370	83120
Salmas	9438	14000	59158
Qare Ziaoddin	3815	7900	19363
Khoy	24798	14500	125869
Ardabil	63132	23760	290847
Meshin Shahr	7143	13000	50148
Khalkhal	9393	10000	29815
Garmy	8127	8300	20367
Bileh Savar	4743	9720	14224
Sarein	968	10000	2352
Lenjan	1137	4900	5328
	1239	4680	20613
	8325	35000	59661
Falavarjan	1027	15000	4527
Fereydan	1425	5000	11756

Table 7 (continued)

City	Q(m^3/day)	Capacity (m^3/day)	Population
Najaf Abad	2896	20000	46009
Jolgeh	1537	1446	5362
Semirom	2465	10350	19260
Mobarakeh	4552	21000	56378
	1863	2000	6968
Shahin Shar and Meymeh	34454	79500	186325
Ardestan	969	4000	6284
Fouladshahr	12123	10000	98826
Kouhpayeh	888	760	5601
Naein	264	300	2075
	2986	4600	25389
Shahrreza	7369	20000	56734
Varzaneh	2264	1700	12857
Khansar	130	6308	1071
Baharestan	11348	17000	87169
Bouein and Miandasht	1330	2500	8037
Isfahan	48255	70000	362500
	98898	145000	619558
	55176	100000	346868
	12249	12000	75986
	154271	180000	901912
Karaj	100778	57120	857000
	48	135	310
Ahwaz	36065	36000	194000
Ilam	30973	46000	163532
Eyvan	3049	8541	10044
Dareh Shahr	1898	9000	10590
Dehloran	3167	12600	18259
Sarableh	495	3245	4059
Mehran	2921	9945	13384
Boushehr	38532	90000	177549
Genaveh	8330	28000	51420
Dwylam	1632	7500	8208
Rey	1615	2200	10000
	1697	2200	9000
Shemiranat	1168	1500	2200
	849	1500	2400
	780	1500	2800
	4456	12600	24500
Damavand	462	750	5000
Pardis	9500	24000	125000
Robat Karim	8358	29154	60000
Eslam Shahr	7255	22000	51821
Pishva	1333	26400	12200
Shahriyar	10000	120000	74857
	375	300	4000
Shahr Qods	24001	28650	146356
Malard	10000	10000	65174
	1800	7776	21732
Tehran	10336	15000	85000
	69496	30000	145000
	3839	4800	42000
	4676	2500	23000
	5161	6480	30000
	1377	864	7000
	566163	450000	2100000
	181584	225000	1050000
Shahr Kord	2500	19600	18599
	41716	54000	233566
Boroujen	12166	17000	69905
Faresan	7777	4748	24333
	4043	3000	13556
Saman	4285	3522	13403
Torghabeh Shandiz	578	2400	4450

Table 7 (continued)

City	Q(m^3/day)	Capacity (m^3/day)	Population
	1648	1350	8050
Torbat Heydariyeh	8217	13000	86863
Gonabad	114	240	2043
Neyshabour	15772	20000	175448
Sabzevar	30890	19300	241493
Golbahar	5105	1000	85454
Birjand	16998	10500	181004
Esfarayen	7121	8000	50901
Bojnourd	12333	19600	104744
Chamran	3990	4000	18805
Dezfoul	25400	38000	53701
Ramhormoz	4919	21000	33000
Sousangerd	9280	41000	4258
Shoushtar	5100	21000	115000
Hoveyzeh	3006	4688	9290
Zanjan	30882	27648	125000
Abhar	6307	14320	29000
Mahneshan	170	3200	5000
Shahroud	1159	30932	29000
Mahdishahr	1080	2400	7800
	2481	3500	18200
Semnan	9079	43560	97000
Damghan	426	17500	7900
	182	750	280
Zabol	20622	21000	106956
Zahedan	5575	47800	199118
Chabahar	364	10601	19539
Shiraz	71263	81216	440000
	10338	10000	60000
Eqlid	6145	6100	37821
Marvdasht	11868	24000	87563
Qazvin	5748	26388	373520
	2971	2661	22000
Takestan	3171	3138	82550
Alborz	3547	3547	24300
Abyek	2037	2222	46056
Bouein Zahra	2299	2361	22500
Qom	13920	18700	83200
	51867	51800	254369
Kashan	7071	80000	52788
Niyasar	270	400	1312
Qorveh	1395	2000	7196
	12739	16000	79657
Marivan	19684	20000	142584
Saghez	33876	33000	169641
Baneh	14976	16000	122819
Sannandaj	120554	99260	429707
Kerman	21590	15552	247165
Kahnouj	3839	7250	13392
Baft	259	624	700
Kermanshah	60000	180000	324000
Qasr Shirin	3640	5200	18700
Paveh	2153	3456	11000
Sare Pol Zahab	8714	10000	31921
Eslam Abad	18476	17500	97745
Gilan Gharb	2901	6671	18541
Hersin	375	375	1300
Dogonbadan	7509	25000	39411
Dehdasht	1912	19000	9623
Yasouj	14010	44100	131831
Bandar torkaman	6146	7600	16284
Bandar Gaz	3997	3100	18780
Kordkouy	6648	5200	15085
Gorgan	13928	30000	105230

Table 7 (continued)

City	Q(m^3/day)	Capacity (m^3/day)	Population
Anzali	4714	20000	13500
Rasht	50374	63000	76000
Roudbar	1665	1728	5000
Lahijan	6966	26000	65000
Khoram Abad	55872	48000	248911
	26231	36000	124455
Pol Dokhtar	2471	2500	29000
Aligoudarz	5942	15000	57196
Sari	18486	24240	137479
Qaemshahr	1372	1136	4234
Jouybar	3065	5220	11753
Babol	29024	109728	90550
Babolsar	7277	241	22640
Nour and Royan	100	100	825
Nowshahr	11473	39744	39717
Arak	50070	58000	226563
	35489	17200	181366
	10126	5000	51524
Tafresh	2446	4205	13650
Saveh	3056	34680	18045
Mahallat	3456	8060	18590
Delijan	7851	5585	46000
Khomein	8831	6600	53705
Ashtiyan	690	3000	3850
Mohajeran	763	1200	4267
	4039	1600	22413
Mashhad	17879	15200	121500
	50318	60000	429800
	25423	25000	250000
	67923	60000	530000
	80186	65000	520000
Bandar Abbas	70805	117504	465822
Collection of islands	582	800	4414
Roudan	548	10886	3262
Hormoz	300	2250	2122
Qeshm	335	335	2300
	267	250	1900
Touyserkan	762	1250	4080
	4320	15840	25245
Razan	2160	5011	10765
Nahavand	4489	17700	21629
Kaboudar Ahang	1627	3564	7185
Hamadan	51594	110000	276568
Malayer	6329	34500	34561
Asad Abad	3067	15552	17226
Taft	348	1062	7300
Yazd	22208	31950	149760
Total	3883510	5337359	22699448

Table 8 Operating parameters wastewater stabilization ponds based on Iranian standard

Parameters	Averaging Time	Units	Concentration
pH	weekly	-	7.5
Do	weekly	mg/L	4-12
Influent BOD	weekly	mg/L	100-300
Outlet BOD	weekly	mg/L	20-50
Coliform and Bacteria	weekly	CFU/100mL	24000
Free Chlorine	daily	mg/L	0.5-2
TSS	weekly	mg/L	40-80

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