

**Investigation of the physical parameters that cause to formation or expansion of Harmful Algae Bloom (HAB) and comparing worldwide records with the Persian Gulf**

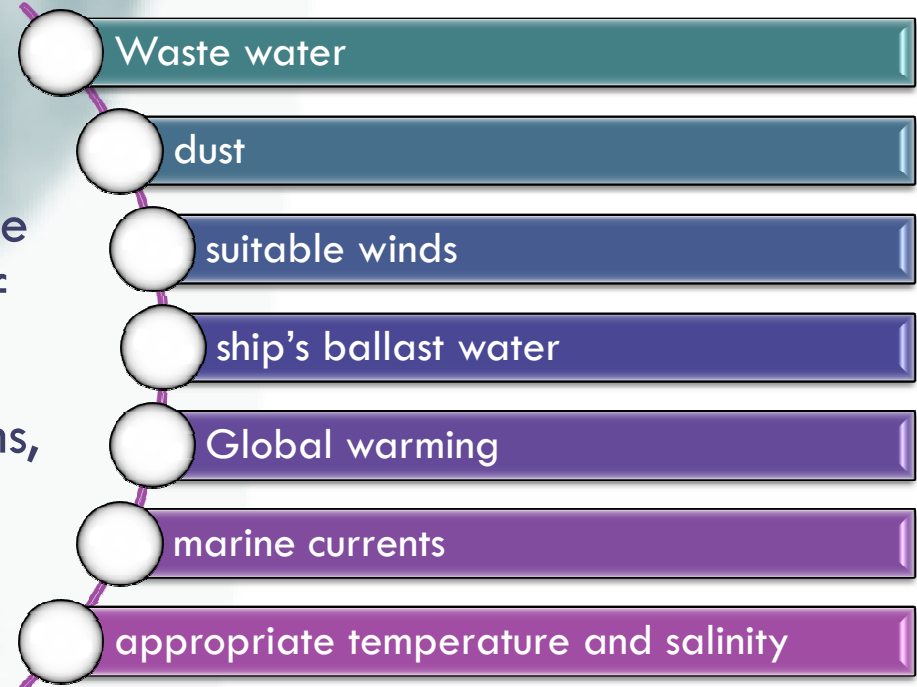
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Effects and problems caused by harmful algal blooms at different scales on various parts of human life and the environment are considerable.

There are several reasons for the occurrence of this phenomenon.

In this article, data related to the red tide has been collected in different parts of the world and has been compared with the case of this phenomenon in 2008 in Iran.

Iran's southern waters are very prone to red tide crises due to all kinds of factors causing the creation and development of harmful algal blooms, including:

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- Waste water
  - dust
  - suitable winds
  - ship's ballast water
  - Global warming
  - marine currents
  - appropriate temperature and salinity



# Introduction



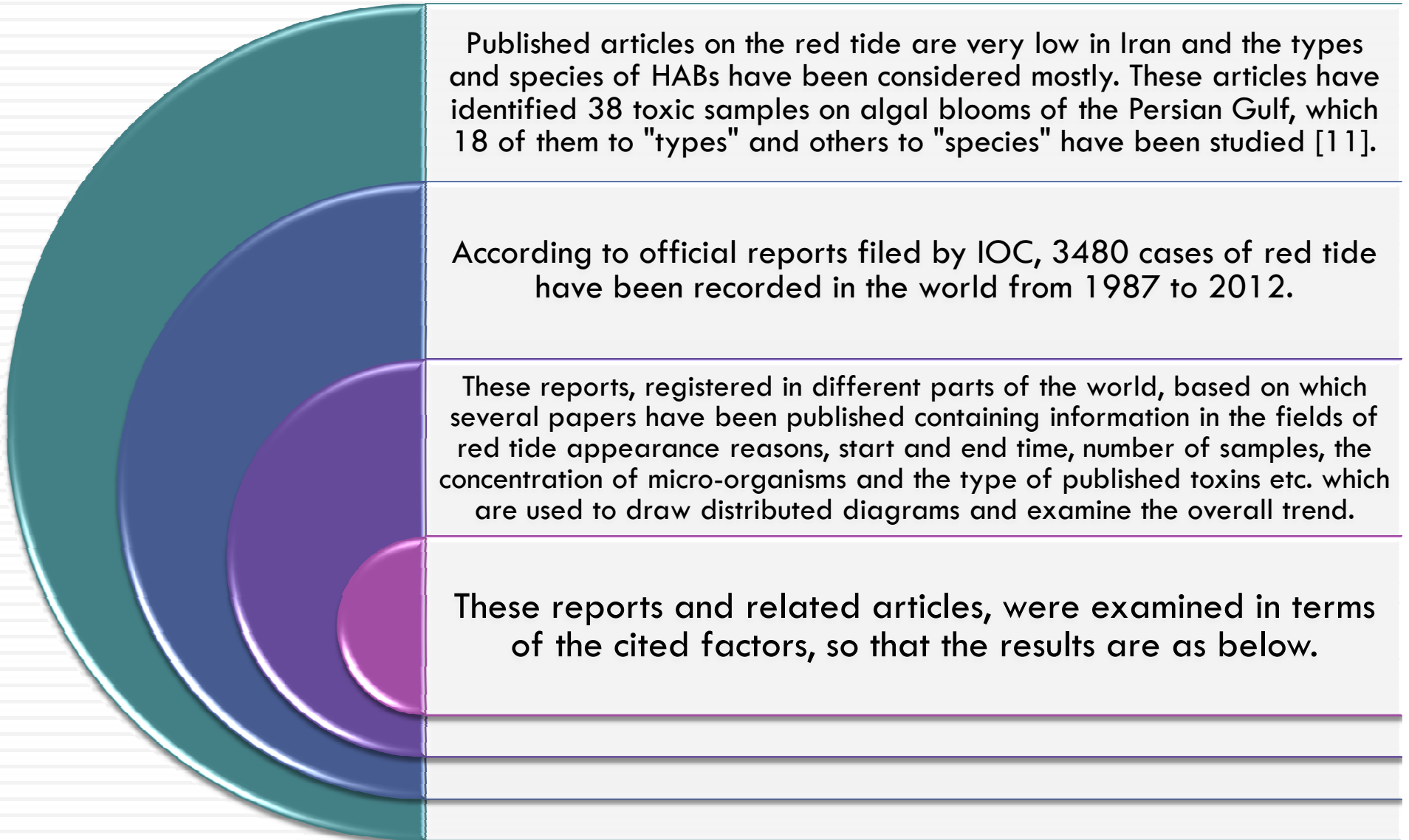
by toxins production and dispersal of strong stench. Although in types of low cell density, not changing in watercolor, but still produced by the algal. The entered toxin can hurt the fishes, syndromes made in fishes through harmful algal are including PSP, neurotoxin (nerve disorder or NSP), amnesia (ASP), and asthma (AZP). Human contact with poisoning fishes causes CFP disease [13].

- Term of harmful algal can be devoted to many species of algal, but HAB share a unique feature that is toxic. These algal have an especial physical structure influencing on the food chain and causing death of other creatures. The rapid growth of the HAB is of other characteristics.
- 1 million phytoplankton algal cells on per liter of seawater, accompanying with the production of environmental toxins is considered algal blooms. Rezai and Senejani [12] have reported 2 to 8 million microorganisms in some areas contaminated by red tide in 2008 in Iran's southern waters.

# *Materials and Methods*

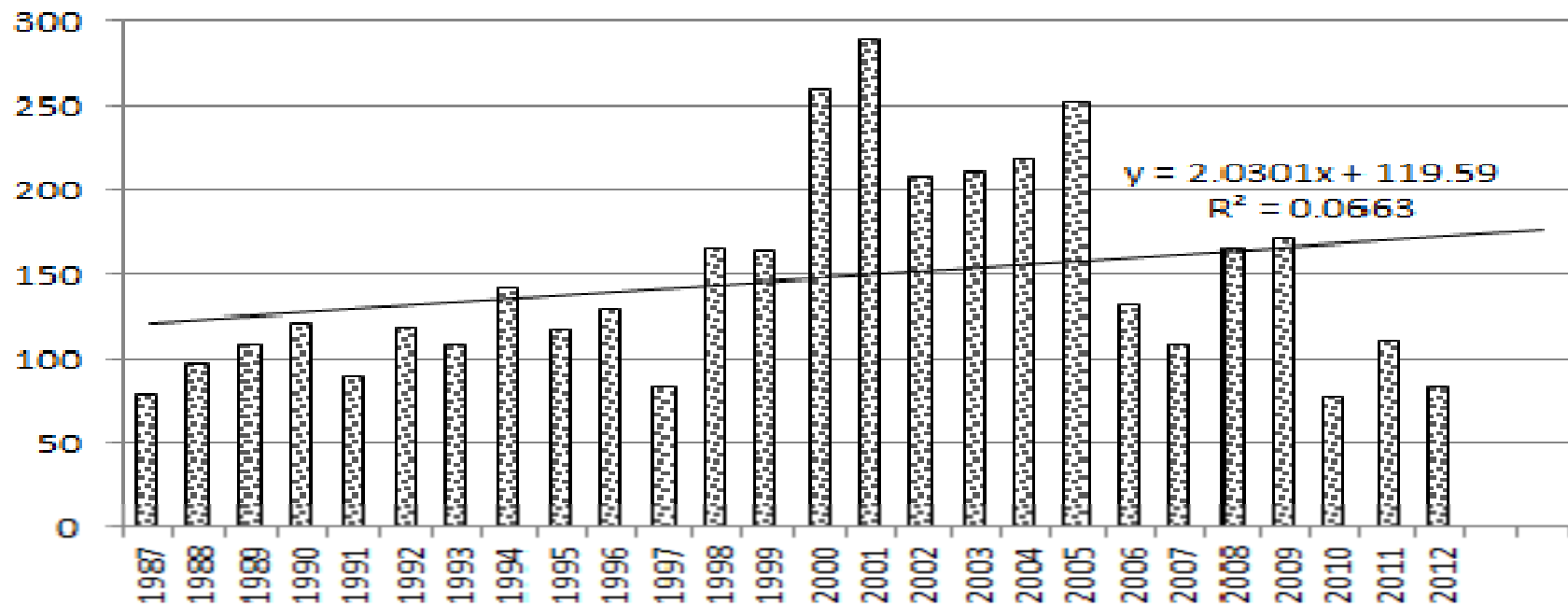
- ❑ In order to scientific prevention or controlling this phenomenon, studying the relevant records in the world and getting more information about the influencing factors is necessary.
- ❑ This phenomenon can be reviewed in terms of biological, bioenvironmental and physical.
- ❑ In this paper, we have collected data, including distribution and characteristics of various types of the phenomenon throughout the world using published articles and available scientific reports and have compared their revolution processes.
- ❑ On the other side, the monthly and annual frequency of the red tide's occurrence was examined that can be applied to investigate the effects of the environmental and climatic changes on this phenomenon.
- ❑ The wind data, temperature satellite data, and salinity data have been used in the Persian gulf and sea of Oman.

# Data Collection and Analysis



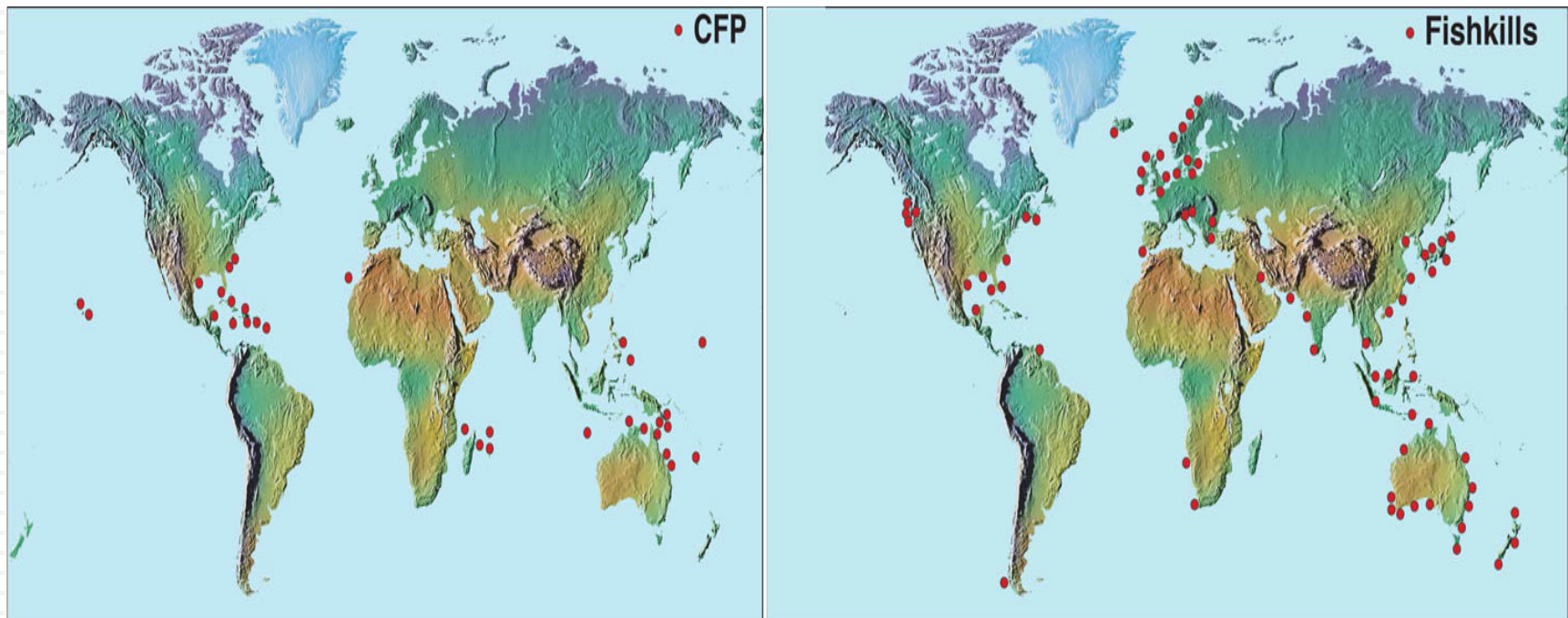
# Results

- Based on data gathered from 1987 to 2012, the annual curve of red tide occurrence was drawn indicating: the highest incidence of this phenomenon was in 2001, 2000, 2005. In 2001, the mortality of 2,500 tons fishes was reported in the Gulf of Kuwait with 850 square kilometers [9]. The annual distribution curve of HAB, demonstrates an ascending general trend to the occurrence of this phenomenon.



*The number of HAB recorded annually, based on the IOC report*

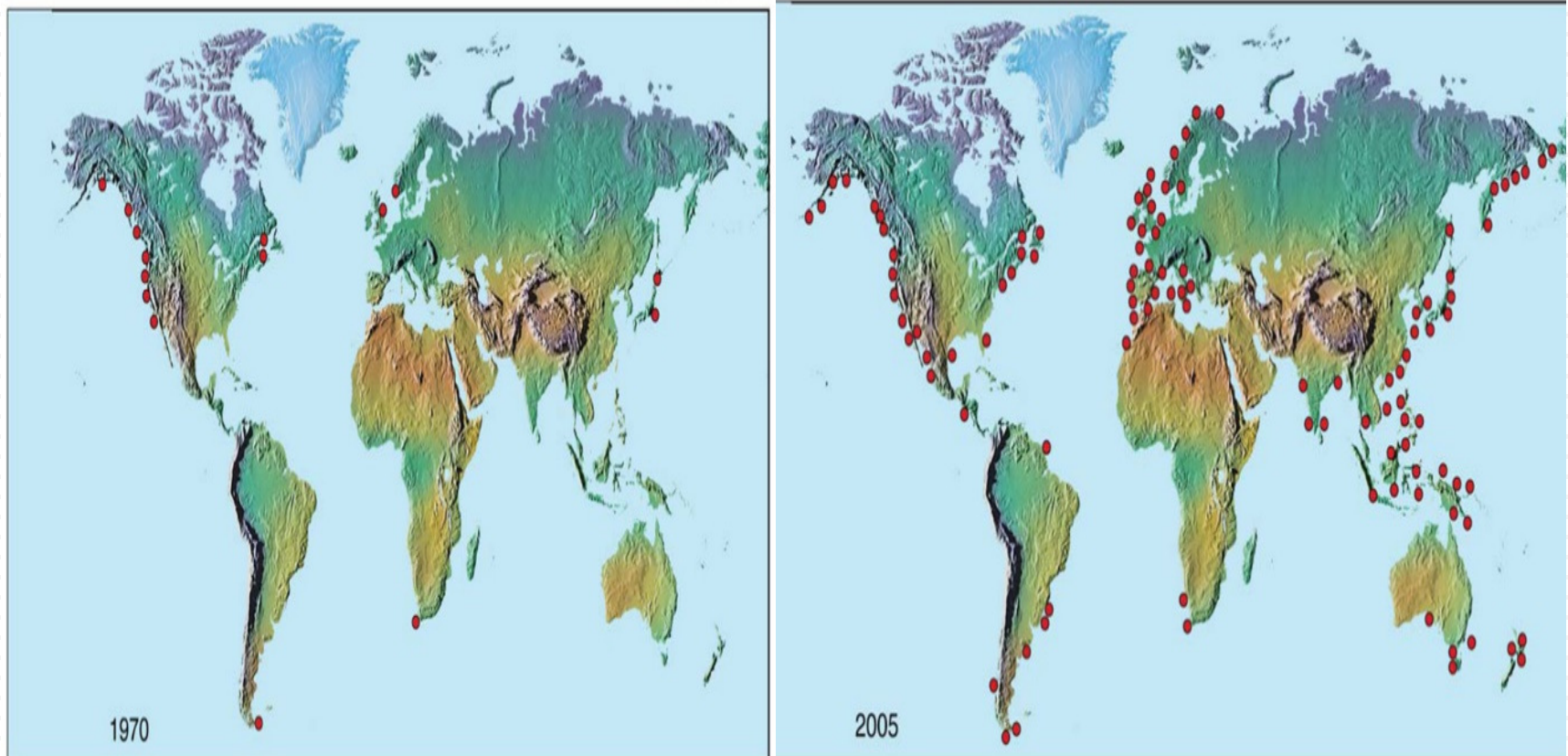
- This Figure demonstrates the universal distribution of related reports of the fish deaths and human disease.
- Long-term presence of algal mass causes a reduction of transparency and inputting light in the depth thus destroys the rich green seabed. HAB in Iran's waters causes death of marine animals through producing nerve toxin (NSP). The algal also have eliminated fish, zooplanktons, and invertebrates by consuming dissolved oxygen in water [12].



*Death of marine organisms until 2012 (right) [25] and CFP disease in humans (left) due to algal blooms phenomena [13]*



This Figure shows the global rise of this phenomenon and the confirmed presence of PSP toxins in fish.



*The process of growing Harmful algal blooms from 1970 to 2005 [13]*



The published articles stating that there is not any agreement on the exact cause of spreading this phenomenon. The first hypothesis says that human activities and water pollution in some areas are the main reason behind this phenomenon.

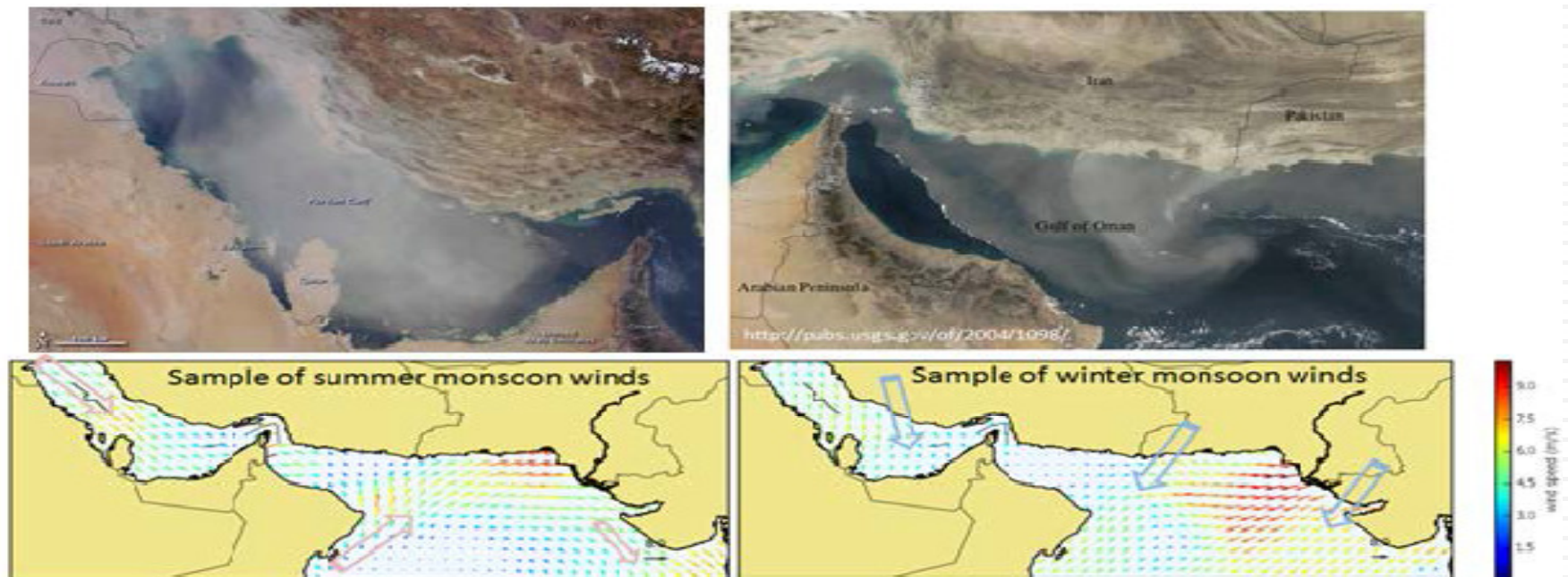


## *Waste Water*

Human activities may cause an area's water richer. In the past decades, the coastal waters have received the sheer large and growing size of industrial and agricultural effluents and domestic sewage in various ways. In many coastal areas around the cities, the entrances have changed the size and composition of the pool water so that can cause the broader and more diverse algal blooms. Therefore, domestic, industrial, and agricultural waters are full of such materials as nitrates and phosphates, which provide a rich platform and increase phytoplankton. In the Persian Gulf and Sea of Oman, there is enormous potential to appear red tide due to the entrance of cities and factory effluents, the oil industry etc. The presence of Iron in surface water controls the spread of algal development.

# Dust

- Windstorms can transfer the iron-containing dust to surface water. combination of iron-containing dust into the water is necessary to stimulate essential nitrogen for growth of toxic algal [15].
- This Figure, showing the satellite images of dust storms in winter over the Sea of Oman and the Persian Gulf in upper part, indicate that the Persian Gulf and Sea of Oman have great potential in the field of creation or development of red tide, regarding to the current dust as sources of Iron. On below part of the shape, the wind patterns drawn in mid-August (summer monsoon) and mid-February (winter monsoon) are seen which are comparable with pictures of above storms.



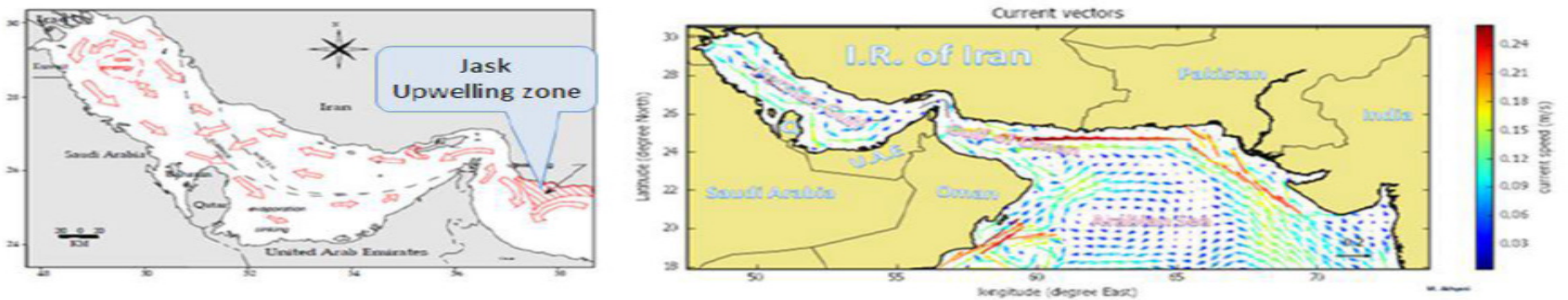
*Satellite Images of dust caused by storm over the Sea of Oman (November 2004) and the Persian Gulf (July) (top) and an example of Monsoon wind pattern (bottom)*

## *Suitable Winds*

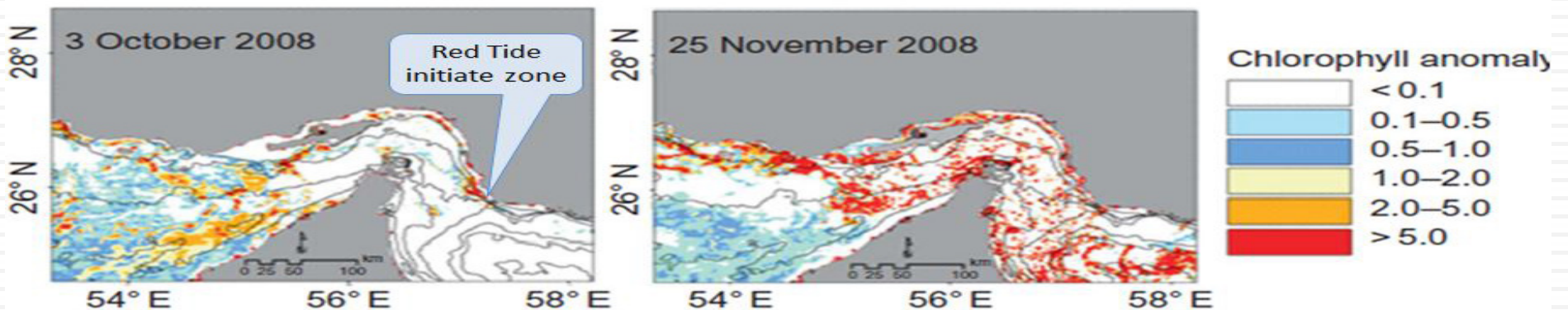
- Winds blow from different directions, cause to transfer the water mass from one point to another one. In a way that, the cold, or rather rich water, controls the algal blooms during upwelling [16]. The upwelling water flow increases the algal blooms rapidly. Entering cold and rich water into the warm water-containing areas and the presence of algal cause sudden growth and increasing of algal blooms. Restarting the upwelling winds, the algal blooms are expanded more and more due to the cold and rich water entrance.
- HAB progress may also occur under the influence of wind on the boundary surface [17]. The wind also influences the characteristics of the mixed layer and circulation pattern of the continent plateau waters.



- In Iran's southern waters, the domestic winds of the Saudi Arabia desert or the seasonal monsoon wind are the probable sources of dust transmission. The direction of monsoon wind changes in summer and winter, and upwelling areas have been identified near the Jask, where was one of the starting points of Red tide in 2008 in Persian Gulf [18]
- In this Figure, an example of the surface flow produced by numerical simulation and pattern obtained by Reynolds is shown [19]. Comparing these images with below Figure showing the data from satellite associated with the red tide in early and late 2008 results in reliable role of upwelling and surface flowing in creating and publishing the phenomenon in the region.



Example of output of the surface flow model in Persian gulf and sea of oman and pattern obtained by Reynolds [18]



Analysis of satellite images of the red tide publication in 2008. [19]

## *Ship's Ballast Water*

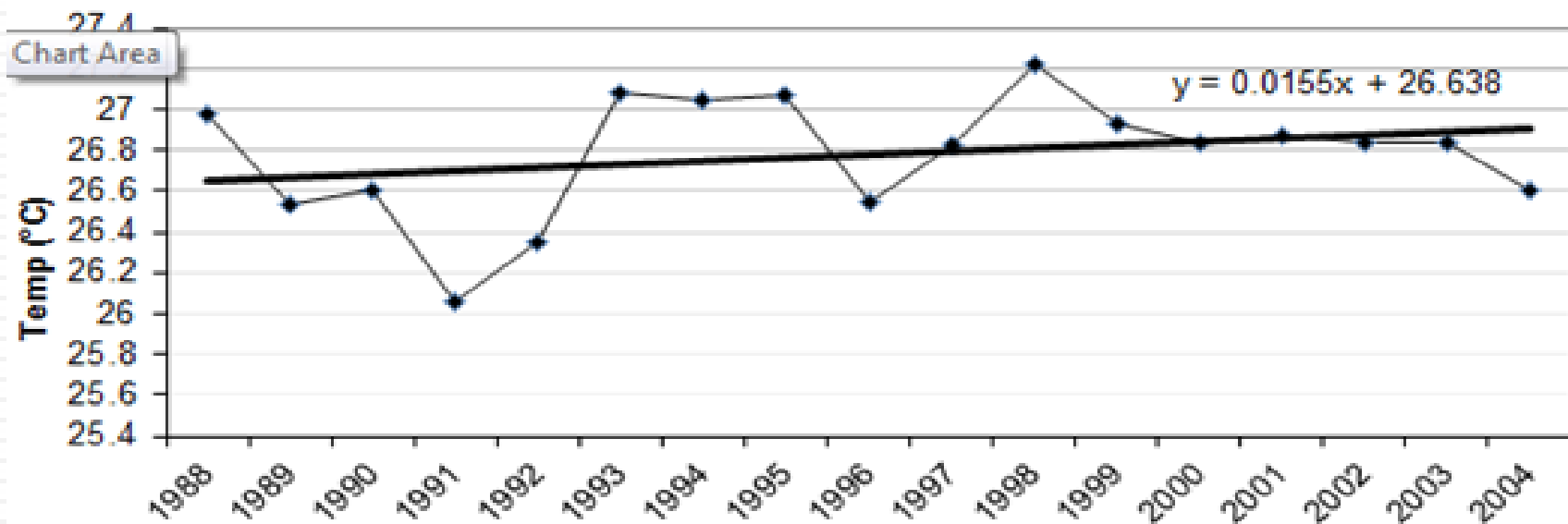


- It is also likely that algal masses are transformed through the ships to different regions [8]. Data shows that approximately 57% of the world's oil reserves and 45 % of world's natural gas exist in the Persian Gulf and Sea of Oman, and more than 30 % of the world's demands for these resources are exported through gigantic floats [20] and they are subsequently prone to be infected through the ships.



# Global Warming

- The algal blooms phenomenon may occur due to natural mechanisms such as climate change one of which is climate warming. Analysis of satellite data shows that the surface temperature of Iran's southern waters is gently increasing as seen in this Figure [21]. Although, based on detailed studies, there is algal blooms in areas where the water pollution - as a factor- is not seen. Organisms that are the main cause of the algal blooms have been existed, thousands or even millions of years ago on the planet chancing to disperse through climate change, the earth's layer movement, and the other world's changes.



Average surface temperature in the Arabian Sea and the Persian Gulf [20].

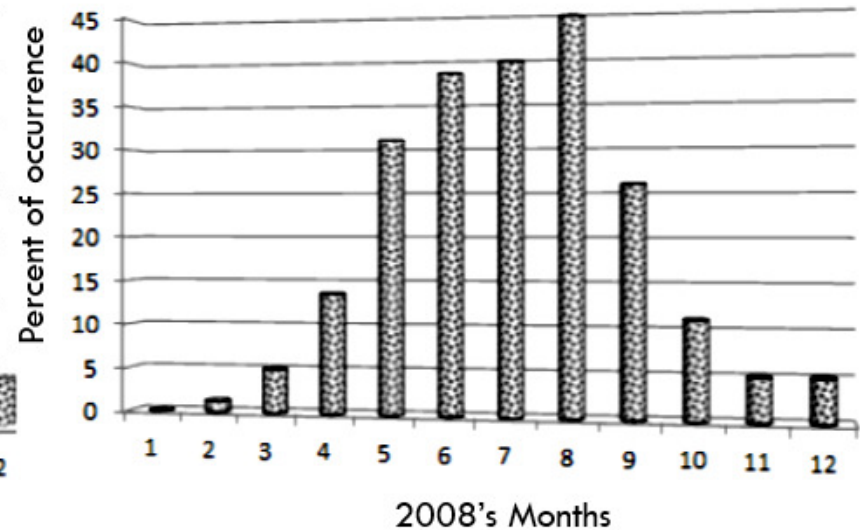
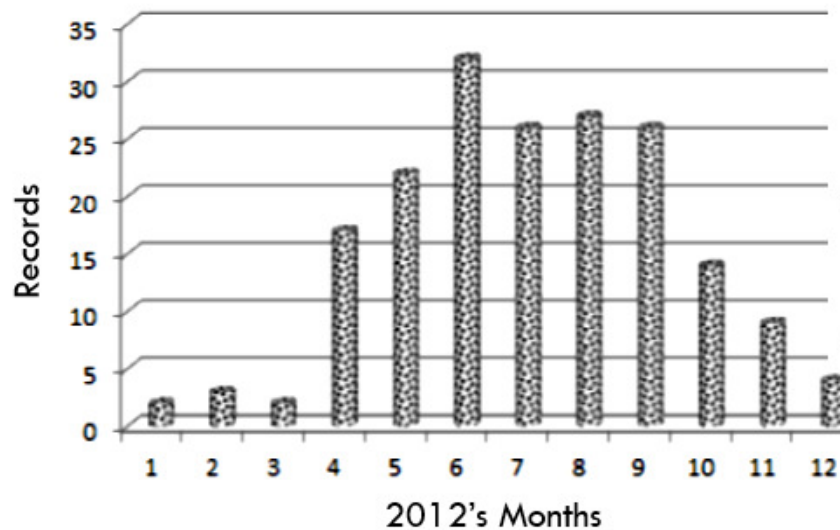


## *Marine Currents*

- Natural events and transmission through offshore flow can be mentioned as reason of the other expansions. For example, the expansion of NSP toxins in North Carolina in USA indicates that 1,500 km Florida algal masses was brought into the area by the Gulf Stream. There is approximately 750 km the development of this phenomenon along with input surface-water flow of the Indian Ocean to The Persian Gulf, from SIRIC port of Oman to the center of the Persian Gulf –Bushehr- [12].
- The deep water of continent plateau usually provides a mosaic bed to transmit the deep stable water, which may contain the HAB Configuration changes. Orientation of coastal waters and seabed topography play significant role in determination of structure manner, the dispersal, and stability of HAB in water [8].

## Appropriate Temperature and Salinity

- Monthly distribution of the occurrence of red tide in the world depicted in this Figure, shows that the algal mass usually occurs in the summer when the water temperature is between 20 to 25 ° C and water salinity is 20 to 30 ppt [22]. The recorded events from November to March relates to the southern hemisphere's summer. The relevant Organisms achieve the fastest growing at temperatures above 20 ° C and salinity more than 20 ppt.
- Water temperature in Iran has been 22.27 to 23.25 ° c during this phenomenon.



*The number of recorded HAB in the world, per month, in 2012 and the occurrence percent in 2008, according to IOC report*

## *Some Of The Most Important Cases Of Harmful Algal Blooms Can Mention As Follows:*



- in 1793 and 2005 in Canada
- in 1850 and 2012 on the Florida coast
- in 1972 in England
- in 1976 on the Malaysian coasts
- in 2011 in the Gulf of Mexico.





# Harmful Algal Blooms in the Persian Gulf and the Gulf of Oman:



- Historical reports on the occurrence and frequency of HABs in the Persian Gulf and Gulf of Oman are scarce
- Several taxa of potentially toxic phytoplankton have been documented in the Persian Gulf and nearby coastal waters, as have red tides resulting in significant fish kills and aquaculture losses
- HABs, In 1999 cause a major fish kill occurred in Iranian coastal waters, which was immediately followed by fish kills in Kuwait Bay
- A review of HAB occurrences in the coastal waters of Oman between 1976 and 2004 showed that about 66 red tide events have been recorded, 25 of which resulted in mass mortality of fish and marine organisms
- 2008–2009 bloom suspected to originate in the Gulf of Oman and was subsequently transported into the Persian Gulf through the Strait of Hormuz by currents



# Conclusion

- According to the above contents, the red tide in countries around the world like Iran has happened in the summer. Water temperature and salinity play a reliable role in any algal blooms that any type of algal reach the maximum rate of cell division in particular range of temperature - salinity.
- Wastewater and other unnatural running waters provide the required food sources of the red tide algal. In order to prevent the hazard of red tide, detailed controlling should be done over this factor, especially in summer. In Iran Bushehr and Bandar-Abbas are the most pollutant places due to municipal and industrial waste and international vessels traffic.
- The wind and marine currents are the most important emission factors of red tide. The surface water mass of the Indian Ocean enters through the Strait of Hormuz along the northern coasts of the Persian Gulf and progresses to Bushehr region. The overcoming wind pattern in the Persian Gulf is along with the red tide blooms in the North West.
- Given the trend of earth warming, the evidence of which was mentioned with the analysis of the temperature of Iran's southern waters, each of the algal blooms phenomena occurring in different parts of the Persian Gulf continually, and have the prone to be a crisis.
- Obviously, the only way to prevent this hazard is controlling and reducing pollution of input water caused by human activities. On the other side, according to the above contents, in order to optimal management of red tide disaster, studying and simulation of the pattern of sea currents, wind and high accuracy waves are necessary to more exact identify the publication velocity and orientation. In addition, sensitivity testing of the red tide algal should be taken place via the environmental ultra-measurement of temperature - salinity etc. which is being done in the world.

**Thank you all  
for your attention**





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