



Government of Jammu & Kashmir
Higher Education Department

E-CONTENT

A Gateway to all Under Graduate Courses

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Quick Notes

- ✓ Also called as tidal waves because of long wavelengths, although the attractions of the Moon and Sun play no role in their formation
- ✓ Tsunami is a Japanese word; 'tsu' = harbor and 'nami' = wave

VIDEO LINK

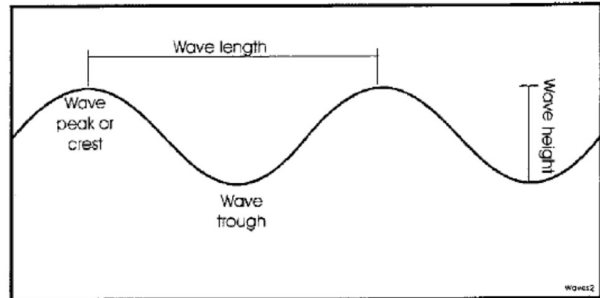
<https://youtu.be/V78KKmkPtBM>

2.4.2 TSUNAMIS

I. INTRODUCTION

Tsunamis are a series of waves caused by violent wave movements on or near the sea floor. The generated waves have extremely long wave length and wave period. The wave length in the open ocean is of the order of 100 to 150 km. Tsunamis can travel between 640 and 960 km/h, about the speed of a Boeing 747 (Jumbo Jet).

The wave period in a tsunami can be anywhere from 5 to 90 minutes apart. Effects can range from breaking waves, a fast-moving tide to a barely noticeable ripple. The first sign of a tsunami can be either a rise or fall in the water level.



Basics of Tsunami Waves

- **Wave crest and trough:** The highest and lowest points of a wave are called the crest and trough respectively.
- **Wave height:** It is the vertical distance from the bottom of a trough to the top of a crest of a wave.
- **Wave amplitude:** It is one-half of the wave height.
- **Wave period:** It is the time interval between two successive wave crests or troughs.
- **Wavelength:** It is the horizontal distance between two successive crests.
- **Wave frequency:** It is the number of waves passing a given point during a one second time interval

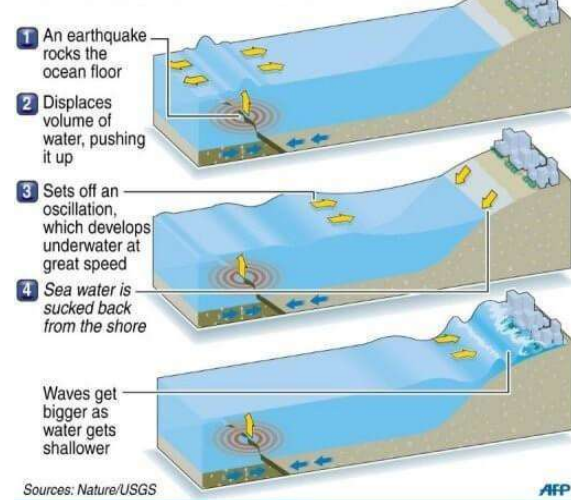
Tsunami Wave vs. Typical Wave

WAVE FEATURE	WIND-GENERATED WAVE	TSUNAMI WAVE
Wave speed	5-60 miles per hour (8-100 kms/hr)	500-600 miles per hour (800-965 kms/hr)
Wave period	5 to 20 seconds apart	10 minutes to 2 hours apart
Wave length	300-600 feet apart (100-200 meters apart)	60-300 miles apart (100-500 kms apart)

II. GENERAL CHARACTERISTICS

- Tsunami in the deep ocean may have very long wave length of hundred of kilometer and travels at about 800 km per hour, but an amplitude of only about 1 km.
- It remains undetected by ships in the deep sea. However, when it approaches the coast its wavelength diminishes, but amplitude grows enormously, and it takes very little time to reach its full height.
- The tsunami is not a single giant wave. It is possible for a tsunami to consist of ten or more waves which is then termed as 'tsunami wave train'. The waves follow each other 5 to 90 minutes apart.

How a tsunami occurs



- Tsunami normally causes flooding as a huge wall of water enters the main land.
- Tsunamis have great erosion potential, stripping beaches of sand, coastal vegetation and dissipating its energy through the destruction of houses and coastal structure.

III. CAUSES OF A TSUNAMI

Tsunamis are caused through violent actions of the Earth. These actions may be earthquakes, landslides, volcanoes, or even from meteorite or asteroid impact. The geological movements that cause tsunamis are produced in three major ways.

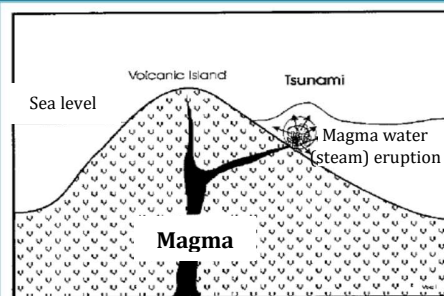
- Earthquakes:** Most tsunamis occur due to large earthquakes under the ocean. The interaction between the large tectonic plates, which make up the surface of the earth, causes the majority of the earthquakes. When the sea floor moves suddenly during an earthquake, it can displace the overlying water. When large areas of the sea floor are elevated or subside, a tsunami can be created [Fault movement that is horizontal causes little or no displacement of water and therefore such earthquakes do not generate tsunamis].
- Landslides:** The second most common cause of the tsunami is a landslide either occurring under water or originating above the sea and then plunging into the water. Landslides are produced when the slopes or deposits of sediment become too steep and the material fails from the influence of gravity. The largest tsunami ever produced by a landslide was in Lituya Bay, Alaska 1958. The massive rock slide produced a wave that reached a high water mark of 50 - 150 meters above the shoreline.

- C. Volcanic Activity:** Tsunamis associated with volcanoes are less common than those from earthquakes, but can still be as destructive. The flank of a volcano located near the shore or under water may be uplifted or depressed similar to the action of a fault, or, the volcano may actually explode. In 1883, the violent explosion of the famous volcano, Krakatoa in Indonesia, produced tsunami measuring 40 meters which crushed upon Java and Sumatra. Over 36,000 people lost their lives in this tyrant waves.

There are three main volcanic processes that cause a tsunami:

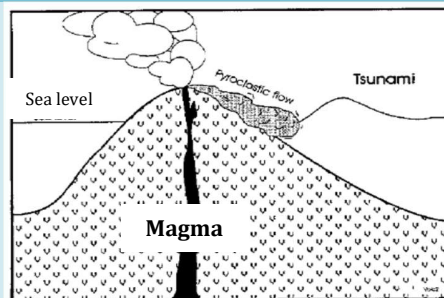
1. Submarine volcanic explosions :

occur when the cool seawater comes in contact with hot magma. It can react violently and produce steam explosions.



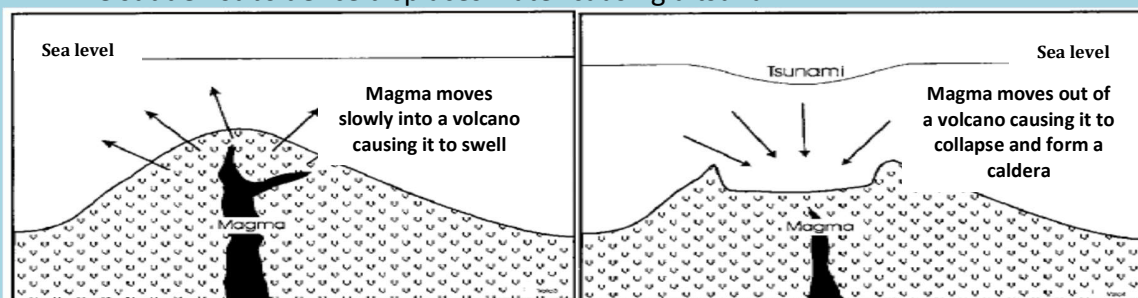
2. Pyroclastic flows:

are the flow of volcanic debris down the flank of a volcano as part of the eruption process. When these flows move rapidly into the ocean they displace water, which may result in a tsunami.



3. Collapse of a caldera:

can occur when the magma beneath a volcano is withdrawn back deeper into the earth. The sudden subsidence displaces water causing a tsunami.



D. Meteorites and Asteroids

As the two-thirds of the earth is covered by water, chances are that when an asteroid or a meteorite actually hits the earth it will land in the ocean. This would be devastating for the most coastal areas due to a devastating tsunami, but the same impact on land would create a dust cloud, which could possibly block the sun for many months.

IX. TSUNAMI VULNERABILITY

Most tsunamis occur in the Pacific Ocean because the Pacific basin is surrounded by the most tectonically active zone. Often referred to as the **Pacific Ring of Fire** (Particularly along the coast of Alaska, Japan, Philippines, and other islands of Southeast Asia, Indonesia, Malaysia, Myanmar, Sri Lanka, and India, etc). The Pacific basin is bounded by the edges of tectonic plates. These interact to form seismically active belts dotted by active (often explosive) volcanoes. Tsunamis also occur elsewhere including the Mediterranean Sea and Indian and Atlantic Oceans.

After reaching the coast, the tsunami waves release enormous energy stored in them and water flows turbulently onto the land destroying port-cities and towns, structures, buildings and other settlements. Since the coastal areas are densely populated, and these are also centres of intense human activity, the loss of life and property is likely to be much higher by a tsunami as compared to other natural hazards in the coastal areas. One of the most devastating tsunamis occurred as a result of the "Great Lisbon Earthquake" of 1755.

By virtue of being surrounded on three sides by Arabian Sea, Indian Ocean and Bay of Bengal India is very much vulnerable to the tsunami related disasters. For Tsunami to hit the Indian coast according to INCOIS (Indian National Centre for Ocean Information Services), it is necessary that the earthquake of magnitude more than 7.0 on Richter scale should normally occur. The possible zones for such an event to occur are Andaman - Sumatra or Makran (Pakistan).

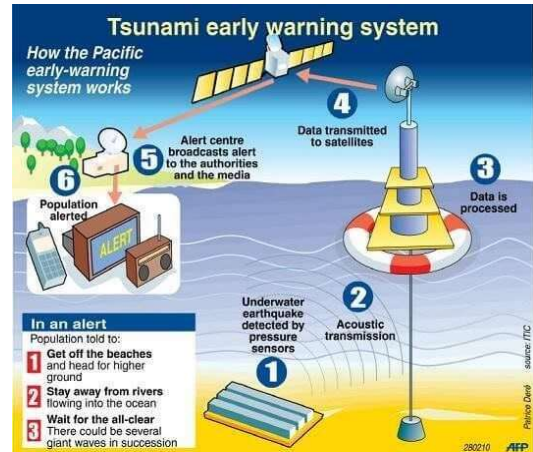
Historical Tsunamis in India		
Date	Cause	Impact
12th April, 1762	Earthquake in Bay of Bengal	Tsunami wave of 1.8m at Bangladesh coast
31st December, 1881	Magnitude 7.8 earthquake beneath the Car Nicobar	Entire East coast of India including Andaman & Nicobar coast was affected by tsunami
27th August, 1883	Eruption of Krakatoa volcano (Sunda Strait) Indonesia	East coast of India was affected and 2 m Tsunami was reported at Chennai.
26th June, 1941	8.1 Magnitude earthquake in Andaman	East Coast of India was affected by tsunami.
27th November, 1945	Earthquake of magnitude 9.1 in the Makran subduction zone (Baluchistan, Pakistan) caused a 12m high wave.	West coast of India was affected by Tsunami
CASE STUDY		
26 December, 2004, Tsunami in Indian Ocean		
<p>Caused by an Earthquake of magnitude 9.1 at Sumatra giving rise to 10m high wave. The Tsunami caused extensive damage to life and property in the states of Tamil Nadu, Kerala, Andhra Pradesh, UTs of Pondicherry and Andaman & Nicobar Islands (A & NI). The Tsunami disaster had badly affected the fishermen community who not only lost their near and dear ones but also lost their means of livelihood. A population of 26.63 lakhs in 1396 villages in five states and UTs was affected by this disaster. Almost 9395 people lost their lives and 3964 people were reported missing and feared dead. Most of the missing persons were from Andaman & Nicobar Islands.</p>		

V. TSUNAMI WARNING SYSTEMS

There are two distinct types of tsunami warning systems:

- International tsunami warning systems and
- Regional warning systems.

Tsunamis have occurred in all the oceans and in the Mediterranean Sea, but the great majority of them have occurred in the Pacific Ocean. Since scientists cannot exactly predict earthquakes, they also cannot exactly predict when a tsunami will be generated.



- International Tsunami Warning Systems:** Shortly after the Hilo Tsunami (1946), the Pacific Tsunami Warning System (PTWS) was developed with its operational center at the Pacific Tsunami Warning Center (PTWC) near Honolulu, Hawaii. The PTWC is able to alert countries several hours before the tsunami strikes. The warning includes predicted arrival time at selected coastal communities where the tsunami could travel in few hours. A tsunami watch is issued with subsequent arrival time to other geographic areas.
- Regional Warning Systems:** Regional systems usually use seismic data about nearby earthquakes to determine if there is a possible local threat of a tsunami. Such systems are capable enough to provide warnings to the general public in less than 15 minutes. In India, the Survey of India maintains a tide gauge network along the coast of India. Apart from the tide gauge, tsunami can be detected with the help of radars. The 2004 Indian Ocean tsunami, recorded data from four radars and recorded the height of tsunami waves two hours after the earthquake.

India's preparedness: The Deep Ocean Assessment and Reporting System (DOARS) was set up in the Indian Ocean post-2004. A National Tsunami Early Warning Centre, which can detect earthquakes of more than 6 magnitude in the Indian Ocean, was inaugurated in 2007 in India. For Tsunami mitigation as well as development strategies in rural and urban areas, the coastal areas can be divided into four hazard zones, with zone 1 as the less dangerous zone and the zone 4 as the most dangerous zone. The zones are defined as:

- Zone-1** maximum water depth 0-3 m
- Zone-2** maximum water depth 3-6 m
- Zone-3** maximum water depth 6-9 m
- Zone-4** maximum water depth > 9 m

VI. TSUNAMI: ADVERSE EFFECTS:

- a) Local tsunami events or those less than 30 minutes from the source cause the majority of damage. The force of the water can raze everything in its path. It is normally the flooding effect of the tsunami that causes major destruction to the human settlements, roads and infrastructure thereby disrupting the normal functioning of the society.
- b) Withdrawal of the tsunami causes major damage. As the waves withdraw towards the ocean they sweep out the foundations of the buildings, the beaches get destroyed and the houses carried out to sea. Damage to ports and airports may prevent importation of needed food and medical supplies.
- c) Apart from the physical damage, there is a huge impact on the public health system. Deaths mainly occur because of drowning as water inundates homes. Many people get washed away or crushed by the giant waves and some are crushed by the debris, causes. There are very few evidences which show that tsunami flooding has caused large scale health problem.
- d) Availability of drinking water has always been a major problem in areas affected by a disaster. Sewage pipes may be damaged causing major sewage disposal problems. Open wells and other ground water may be contaminated by salt water and debris and sewage. Flooding in the locality may lead to crop loss, loss of livelihood like boats and nets, environmental degradation etc.

VII. GLOSSARY

Arrival Time: Time of arrival of the first wave of a tsunami at a particular location.

Coastal Area: The area of land behind the sea coast up to the zero inundation line during the estimated future tsunamis and beyond the coast in the sea requiring tsunami management; the area on the landward side of the mean water line and the area up to 5m water depth on the seaward side of the mean water line.

Estimated Time of Arrival: Computed arrival time of the first wave of a tsunami at the coast after the occurrence of specific major disturbance in the ocean like earthquakes, landslides, volcanic activity in the ocean, meteorite impact on the ocean surface, etc.

Far field Tsunami: A tsunami capable of widespread destruction, not only in the immediate region of its generation, but across the entire ocean basin.

Inundation Distance: The distance that a tsunami wave penetrates onto the shore, measured horizontally from the mean water line.

Intensity: Intensity is the degree of damage caused by a tsunami.

Near-Field Tsunami: A tsunami from a nearby source, generally less than 200 km or associated with a short travel time of less than 30 minutes.

Regional Tsunami: A tsunami capable of destruction in a particular geographic region, generally within about 1000 km of its source. Regional tsunamis also occasionally have very limited and localized effects outside the region.

Tsunami: A Japanese term meaning "harbour wave", derived from the characters "tsu" meaning harbour and "nami" meaning wave, to describe a system of ocean gravity waves having a long wave length and period (time between crests), formed as a result of large-scale disturbance of the sea caused by an earthquake.

Vulnerability Line: Vulnerability line is a setback line to be demarcated on the coastal stretches, taking into account the vulnerability of the coast to natural and man-made hazards.

VIII. ASSESSMENTS-SHORT QUESTIONS

- 1) Discuss ways by which a tsunami can be generated.
- 2) Compare and contrast tsunami waves with normal wind-driven ocean waves in terms of
- 3) their wavelength, period, velocity, and amplitude.
- 4) What are various characteristics of Tsunami waves?
- 5) What are the best ways to mitigate against casualties and damage from tsunami?

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- <http://quake.usgs.gov/tsunami/> Tsunamis and Earthquakes, USGS, USA
- www.asc-india.org Amateur Seismic Centre is a comprehensive website carrying details of state wise seismicity for the country. This also has extensive reports on various past Earthquakes/ Tsunamis.
- <http://www.prh.noaa.gov/pr/itic/> International Tsunami Information Center, Honolulu, Hawaii
- <http://www.tsunami.org/> Pacific Tsunami Museum site. Includes answers to frequently asked questions, links, and information related to Pacific Ocean tsunamis.
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