EROSION AND FLOODING: DYNAMICS AND IMPACT

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Abstract

This paper is a general overview of the processes of flooding. Special emphasis is placed on stream channel flow and how it reaches flood stage. The various forms of transported sediments during stream channel flow and their subsequent deposition as a result of decrease in velocity are discussed. Attempt has been made to explain the recurrence interval of floods and how floods can be forecast using data collected from a stream channel. The study discusses the dynamics of flooding such as velocity, gradient, discharge, shape and roughness of the stream channel, their causes and the dangers they pose to the environment and society arc also discussed. Some control measures on how to manage Hooding arc also proffered.

Introduction

Flood is a large amount of water that has over flown from a source (stream channel, broken pipe, river, lake, dam, reservoir, etc;) on a previously dry area of land (Encarla Dictionaries, 2007). In recent years, there has been the problem of flooding worldwide which may be as a result of high intensity rainfall and global warming. The occurrence of flood in the year 2007, in various places in Nigeria has been alarming. According to Shobayo (2007), flood in August, 2007 claimed over 80 lives in the southern part of Plateau State. In a related development, Azeez (2007), also reported that flood- destroyed-200 houses—-farmlands rendered over 1,000 people homeless in Ikara Local Government Area of Kaduna State in September, 2007. Also, on radio and television the news of flood occurrence in different parts of the world were on regular basis the year 2007.

This paper is aimed at discussing the dynamics and impact of flood on the environment with respect to the causes, the effects and how they may be controlled and managed and the discussion is limited to flooding as a result of stream channel flow.

Stream Transportation and Deposition of Sediments

The rock particles and dissolved ions carried by streams are suspended load, bed load and dissolved load according to Plummer *et al.*, (2003). Sudden decrease in velocity can result in deposition of these loads by streams. Within a stream, discharge varies with position, and if sediments get to the lower discharge part of the stream, sediments will come out of the suspension and arc deposited. As the velocity increases, as it might be during a flood, the stream will overflow its banks onto the flood plains where the discharge is suddenly decreased. This results in deposition of features such as levees and flood plains, terraces, alluvia! fans and deltas *(Nelson, 2006)*.

Flooding

Flood occurs when the discharge of a stream becomes too high to be accommodated in a normal stream channel. When the discharge becomes too high, the stream widens its channel by overtopping its banks and flooding the low lying areas surrounding the stream. The areas that become flooded are called flood plains.

Floods, as considered by Bolt et al., (1975), are river flows that cause or threaten damage, and are produced in a number of ways in which some of them relevant to this work are considered below:

- **Flash flood: -** this is a sudden and often destructive surge of water down a narrow or sloping ground, usually caused by heavy rainfall and lasts for a short duration.
- **River flood: -** this is the destructive surge of water from a river on flood plains as a result of rainstorm.
- **Flood from Structural Failures: -** such as that of a dam or a levee and the flood that results from the melting of glacial ice, landslides or release of volcanic lake.
- **Sheet Flood: -** results from inadequate storm drainage in a community from high intensity rainfall which inundates homes and agricultural land.

- Flood recurrence interval helps us to build flood control systems that can accommodate a certain magnitude of flood for safety.

- **Flood Recurrence Interval and Forecasting**

- To minimize flood damage and loss of life, it is essential to know the potential size of large floods and how often they may occur. For example, a 100 - year flood is the largest flood expected to occur within a period of 100 years. This does not mean that a 100 - year flood occurs once every century, but that there is a 1 - in - 100 chance, or a one percent probability, each year that a flood of this size will occur. Therefore recurrence interval is the probability of occurrence of a particular precipitate event. Two main types of floods impact on society and the environment; river and flash floods according to Microsoft Student with Encarta (2007). As a result, it is their predictions that are described here.
- River flood forecasting involves the consideration of many factors. These include the characteristics of a river basin (such as soil type, ability to hold water and slope) how water behaves in the river and meteorology. Another important factor is how people respond to warnings. For flash floods it is important to observe rainfall rates and the flow of water in a stream. Increasingly, scientists track rainfall by using advanced radar systems that can measure where the waterfalls and with water intensity. They monitor a river using low tech gauges positioned at key locations along a channel. This information is put into computer models that calculate the future volume and height of a river at particular locations.
- **The Dynamics of Flooding**
- Stream channel flooding is controlled primarily by a river's velocity and to a lesser extent, by its discharge. The velocity is largely controlled by the stream's gradient, channel shape and roughness according to Plummer *et ai, 2003.*
- **Velocity:** - the distance water travels in a stream per unit time is the stream's velocity. The cross -sectional view of a stream shows that a stream reaches its maximum velocity near the middle of the channel. When a stream goes round a curve, the region of maximum velocity is displaced by centrifugal force towards the outside of the curve.
- The stream velocities at which sediments are eroded, transported and deposited depend on the grain size as shown in Fig. 1. The upper curve represents the velocity at which previously stationary grains are first picked up by moving water. The lower curve represents the velocity below which deposition occurs, when moving grains come to rest. Between the two curves the water is moving fast enough to transport grains that have already been eroded. Point A in Figure 1, represents fine sand on the bed of the stream that is barely moving.

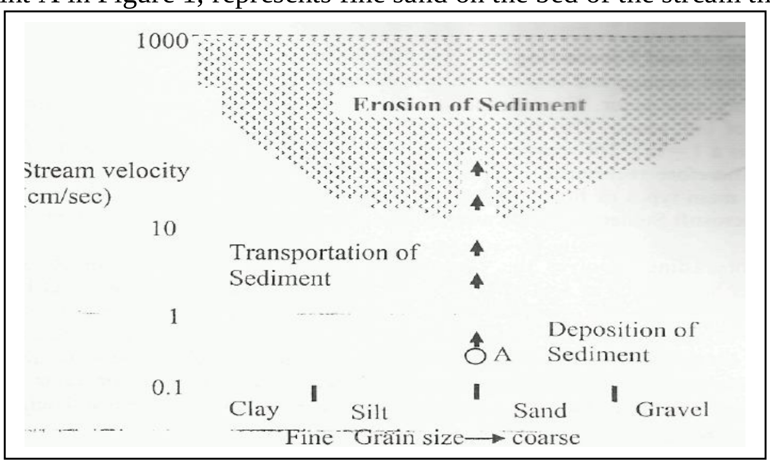

Figure 1. Logarithmic sketch graphs showing the stream velocities at which erosion and deposition of sediment occur. These velocities vary with the grain size of sediment. (After Plummeretal., 2003).

The vertical arrows represent a Hood with gradually increasing stream velocity. No sediment moves until the velocity is high enough to intersect the upper curve and then move into the area marked "erosion". As the flood recedes, the velocity drops below the upper curve and into the transportation area. Under these conditions the sand that was already eroded continues to be transported, but no new sand is eroded. As the velocity falls below the lower curve, all sand is deposited again, coming to rest on the stream bed.

The right half of Figure 1, shows that coarser particles require progressively higher velocities for erosion and transportation. The erosion curve also rises toward the left of the Figure which shows that fine - grained silt and clay are actually harder to erode than sand. The reason is that molecular forces tend to bind sill and clay into smooth, cohesive mass that resists erosion. But once silt and clay are eroded, however, they are easily transported. As can be seen from the lower curve, the silt and clay in a river's suspended load are not deposited until the river eventually stops flowing.

Gradient: - A stream's gradient usually decreases downstream. Usually, the gradient is greatest in the headwater region and decreases towards the mouth of the stream.

Channel Shape and Roughness: - the shape of the channel also controls stream velocity. Flowing water drags against the stream banks and bed, and the resulting friction slows the water down. If two streams A and B have the same cross-sectional area, the stream B will flow slower than A because of the wide shallow channel, since B has more surface area for the moving water to drag against, while A will flow faster if its channel is narrow.

A stream may change its channel width as it flows across different rock types. Hard resistant rock is difficult to erode, so a stream may have a relatively narrow channel in such a rock, as a result it flows rapidly. If a stream flows onto a softer rock that is easier to erode, the channel may widen, and the river will slow down because of increased surface area dragging on the flowing water, as sediments may be deposited as the velocity decrease.

The width of stream may be controlled by factors external to the stream. A landslide may carry debris onto a valley floor, partially blocking a stream's channel as the constriction causes the stream to speed up as it flows past the slide, and the increased velocity may quickly erode the landslide debris carrying it away downstream. Human activities on a river can influence and promote erosion and deposition. For example, the construction of a culvert or bridge can partially block a channel increasing the river's velocity. If the bridge was poorly designed, it may increase the water velocity to the point where erosion may cause the bridge to collapse.

The roughness of the channel also controls velocity. A stream can flow rapidly over a smooth channel (laminar flow), but rough boulder-stream channel flow creates more friction and slows down the flow (turbulent flow). Coarse particles increase the roughness more than fine particles and a simple or wave sand bottom is rougher than the smooth sand bottom.

Discharge: - the discharge of a stream is the amount of water passing any point in a given time. It is found by multiplying the cross - sectional area of a stream by its velocity.
Mathematically,

Discharge (m^3/sec) = Cross - Sectional Area (Width x Average Depth) (m^2) x Average Velocity (m/sec).

As the amount of water in a stream increases, the stream must adjust its velocity and cross-sectional area in order to form a balance. Discharge increases as more water is added through rainfall, tributary streams, or from ground water seeping into the stream. As discharge increases, generally width, depth and velocity of the stream also increase. The increase in velocity of the stream may cause the stream to overflow its channel resulting in a flood if there is no corresponding increase in width and depth of the stream channel,

Causes of Flooding

The rate and magnitude of flooding may be caused by the following factors:-

Rainfall Intensity and Runoff: - The impact of raindrops on the soil surface can break down soil aggregates and disperse the aggregate materials. Lighter aggregate materials such as very fine sand, silt and organic matter can easily be removed by the raindrop splash and runoff water, greater raindrop energy or runoff amounts will be required to move the larger sand and gravel particles. High rainfall intensity implies high runoff which may lead to flood.

Slope Gradient and Length: - Naturally, the steeper the slope of a field, the greater the amount of soil loss from erosion by water. Soil erosion by water increases as the slope length increases due to greater accumulation of runoff and may result to flood. Consolidation of small fields into larger ones often results in longer slope lengths with increased erosion potential, due to increased velocity of water which permits a greater degree of carrying capacity of sediments.

Vegetation: - Soil erosion potential is increased if the soil has no or very little vegetative cover of plants and / or crop residues. Plants and residue cover protect the soil from raindrop impact and splash; this protection tends to slow down the movement of surface runoff and allow excess surface water to infiltrate. Where there is no vegetative cover implies high volume of runoff thereby, leading to flood.

Deforestation: - The loss of protective cover through over-grazing, ploughing and fire makes the soil vulnerable to being swept away by water. In addition, over-cultivation and compaction cause the soil to loose its structure and cohesion and become easily eroded and lead to flood problems.

Ditch Bank Erosion: - Poor construction or inadequate maintenance of surface drainage systems leads to bank erosion and flash flood problems.

Land Exploitation: - the exploitation of land for mineral and oil often leave the sites degraded and vulnerable to erosion and flood.

Precipitation: - Water flowing into one part of a stream is balanced by water flowing back to the ocean, but sometimes the amount flowing into one area is greater than the capacity of the system to hold it within natural confines. The result is a flood; combination of factors along with exceptional precipitation can also lead to flooding. For example, heavy snow melts, water saturated **ground,** unusually high tides, and drainage modifications when combined with heavy rain can lead to **flooding.**

Dam and Levee Failures: - Dam occurs as both natural and human constructed features. Natural dams are created by volcanic events (lava flows and pyroclastic flows), landslides or blockage by ice. Human constructed dams are built for water storage, generation of electric power, and flood control. All types of dams may fail with sudden release of water into the downstream drainage. The levee systems designed to prevent flooding can also fail and lead to catastrophic flooding.

Effects of Flooding

The direct damages from flooding to the environment and society include:-

Phy steal. Damage:

- Loss of productive land due to erosion.
- Structures such as bridges, dams and houses gel damaged and landslides may be triggered.
- The washing out of lakes, loads and fence rows due to erosion.
- Navigation and hydroelectric power are often impaired.
- Flood damage roads making them inaccessible to vehicles.
- Prolonged high floods delay traffic and interfere with economic use of land.
- Spawning grounds for fish and other wild life inhabitants arc often destroyed.
- Financial losses due to floods and erosion is commonly in billions of naira each year.
- The erosion and subsequent deposition of weathered sediment of the landscape lower the ground and levels it through removal of rock debris and filling in low places by deposition as the flood recedes.
- Floods cause soil erosion as well as sediment deposition problem downstream.
- Floods disrupt normal drainage systems in cities and typically overwhelm sewer systems.

Agriculture

- Shortage of food crops can be caused due to loss of entire harvest.
- Failures of crop produce due to loss of seeds and fertilizer.
- Floods can distribute large amount of water and suspended river sediments over vast areas. In many areas, these sediments help replenish valuable topsoil components to agricultural lands.

Water Supply

- Floods contaminate water making clean drinking water to be scarce.

Casualties

- People and livestock die due to drowning. It can also lead to epidemics and diseases.

Recommendations

The damage done by flooding to the environment and its inhabitants needs to be put under control as such the following suggestions will go a long way in bringing their effect under control that can be managed as follows:

- Diversion structures may be constructed to reduce the volume of flow over on bare slopes and surface roughening techniques can be used to reduce effective slope length of the surface by breaking up sheet flows.
- Flood walls of concrete should be built to protect cities from flooding.
- There should be mapping of the flood prone areas.
- There should be land use control where major development is restricted in areas subject to flooding.
- Defences such as levees, bunds, reservoirs and weirs should be built along, *rim* baulks to prevent rivers from bursting their banks.

- Geophysical investigations of dams should be carried out regularly to ascertain the strength or fractures/faults that may result to dam failures to avert future floods.
- The emergency response infrastructure and early warning systems (flood stations, flood alarms e.t.c.) for natural disasters like flooding should be prompt to their service.

Conclusion

A natural disaster such as flooding which threaten and pose damage to lives, valuable properties and the environment deserve to be treated with sensitivity by government, and non-governmental organizations. The control measures that will help to manage and reduce the damage to its bearest minimum should be put in place and those measures that need to be enforced should be done to their logical conclusion and where flood does occur the emergency relief agency should be prompt to rescue victims as it is done in advanced countries.

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