Chapter 1

Introductory Chapter: Sustainable Development and Sediment Engineering

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Additional information is available at the end of the chapter

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1. Sediment

Due to their importance to social growth, environmental and economic issues, surface erosion, sedimentation, scour, and deposition have been investigated by engineers and geologists for centuries. Solid fragments of naturally occurring organic or inorganic materials with a particle size of less than 2 mm are named fine sediment, which is broken down by the processes of weathering and erosion. The fine sediment generally includes sand, silt, and clay particles. Particles greater than 2 mm are categorized as coarse sediments which includes gravel, cobble, and boulders. These materials become detached from the rocks and are transported to a deposition site such as streambeds and lakes by the action of water, ice, wind, and force of gravity. In this process, sediments may be affected by cementation, consolidation, solution, or biological action. The physical and biological characteristics of stream systems are influenced by sedimentation. Apart from human activity, the level of deposited and suspended sediments in each stream depends on climate, geology, and terrestrial characteristics of a stream's watershed. The process of erosion is natural, while the human activities can greatly intensify the process of erosion and sediment transportation [1]. In the function of watershed or aquatic ecosystems, sediment plays vital role and can has a positive or negative effect on stakeholders and biota.

2. Human effects on sedimentation

Surface erosion from watersheds and bank erosion along the river caused sedimentation in all water bodies. As a result of earth-forming developments, for instance climate, glaciations, weathering, and geologic events, some characteristics of a basin such as slope, soil

composition, elevation, and size have formed throughout centuries. The contributions of these characteristics are different in each watershed. However, in a watershed, there is a historic adaption between the livelihood of the aquatic life and the amount and characteristics of the sediment of stream system. Management at the watershed scale is a main challenge facing existing and coming generations. Many of the environment ecosystems are being dishonored or being used in an unsustainably manner [2]. Degradation of waterways in a watershed was intensified a result of human activities which aims to convert the home-grown vegetation to land uses related to agriculture and urbanization. These changes increasingly disturb the local hydrological cycle creating problems with stream flows, erosion, and sedimentation [3]. Apart from land use change, river canalization, water pumping, inter basin water transfer, logging, road construction, gravel mining, and mega hydraulic structures like dams are commonly considered unnatural contributors to sedimentation [4]. As common human activities, agricultural land development and urbanization within a stream's watershed often increases excessive quantities of sediment to water ways. In addition, the stream habitats and water quality are influenced by human activities. Excessive sediment inputs from the disturbed lands reduce water quality in watersheds. **Figure 1** shows agricultural land development in a steep hill in KhorKoreh watershed, Kurdistan Iran, destroying the land cover and making it more erodible.

In contrary, for runoff and sediment storage purposes, numerous watershed practices are currently being implemented, which improved the hydrologic conditions in watersheds [1]. To increase water infiltration and to decrease runoff and sediment flow into streams and water bodies, structural measures such as the construction of check dams and nonstructural management such as biological treatment have been practiced worldwide [1]. However, to measure the effectiveness of these activities, consistent assessments are essential. In many cases, the misconducting of man-made structures intensifies the watershed erosion. **Figure 2** shows the downstream of a stilling basin of a constructed check dam in Kurdistan, Iran. The dimensions of the stilling basin are too small to diminish the flow velocity, and the accelerated

Figure 1. Agricultural land development as a common human activity caused surplus sedimentation.

Figure 2. Misconducting of a check dam on a water way.

flow degrade stream condition washed out the stream bed, which caused bed deformation passing through stream bed.

3. Sustainable development and sedimentation

Understanding the aspects and principles governing the river processes is essential for engineers. An unquestionable method to shorten the useful life of hydraulic structures like lakes, reservoirs, and wetlands is sedimentation. In line with sustainable development and integrated water resources managements (IWRM), all the aspects of environment, social, and economic issues must be considered in the planning, design, construction, and operation of any water project. Even, for current projects, evaluation methods should be developed and applied to reassess their advantages considering the principle of IWRM. Ecosystem restoration and waterway recreation are considered, by researchers and engineering, as a way to attain sustainable development [5]. In recent years, to restore a river's environment, many existing hydraulic structures were modified or redesigned [5]. Accordingly, some of the hydraulic structures may need to be decommissioned. Reasons for withdrawing include, structure security and safety, legal and economic liability, and environmental considerations. A sedimentation management method for reducing watershed erosion to reduce sediment inflow and sluicing sediment from hydraulic structures is a way to increase useful life of constructed structures. Engineering design and construction of hydraulic structures, without considering a river as a dynamic system, and taking IWRM principles into consideration may not serve the basic functions of rivers.

4. Sedimentation engineering

Sedimentation engineering involves sediment issues in the development, use, and conservation of water and land resources. The guidance to theoreticians and practitioners' worldwide, concerns the hydraulics of sediment transport in fluvial systems. In fact, sedimentation engineering is an effort to relate the mechanics of sediment transport in waterways and by turbidity

flows to the morphodynamics of reservoir and lake sedimentation, with the development of fluvial deltas [6]. The gravity force from the differences in density between particles and the fluid are the main cause for sedimentation of particles. In flowing water, the sediment particles, because of the gravitational forces and the upward-acting lifting forces induced by the flow, remain suspended. For particles denser then water, the gravity forces is dominant in comparison with the upward-acting lifting forces and the particles fall through standing water. Sediment entrainment and transport maintenance are two fundamental independent processes of bed material movements. Numerous methods to estimate and evaluate the mechanisms' quantity and effects of both suspended and bed sediment loads are presented by sediment engineers. Apart from increasing sediment loads in watersheds, water bodies, and industrial, the contemned sediments are the challenges that affect the environments. Contaminated sediment may exist in streams, rivers, wetlands, lakes, along ocean margins, harbors, reservoirs, or in other water bodies. The contaminants may have man-made or natural sources like many metals and some organic compounds. Principles of the cleanup process are complex at sediment sites and sites with soil or ground water contamination. As noted above, in recent years, refreshing urban areas and returning land and water bodies to creative uses have become increasingly important. In these efforts, protecting or re-establishing a natural riparian corridor along the stream is considered as the most proper ecological option.

To the achievement of river engineering design, actions, and maintenance, our considerate of the dynamic stability between amount of sediment loads in a stream and sediment source from upstream is important. In sedimentation engineering, theories of erosion, sediment transport, and deposition are considered to alter the knowledge about human interaction with environment to diminish the inappropriate effects of projects on environments. To simulate and predict sedimentation processes in a basin, a systematic method based on reliable theories can be used. For such reasons, numerous models are presented and accessible for engineers to be used for analyzing sedimentation problems in various watersheds, waterways, and waterbodies. However, several of the complicate aspects and principles of sedimentation are yet to be understood, and they remain among the challenging subjects for upcoming investigations.

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