The Rainfall Erosion of Polish Soils (2006-2016)

Nibal Kh. Mousa*, Ali R. Ali, Waleed I. Abdullah
Environment and Water Directorate, Ministry of Science and Technology, Baghdad, Iraq.
Correspondence to: Nibal.Mousa@mail.co.uk

Abstract

The study aims to live the rainfall erosion effect on Polish soils from (2006-2016). the very best Rainfall erosion in Polish cities were in Kasprowy Wierch and Śnieżka (1722.4, 579.59 MJ mm ha-1 year-1) respectively, thanks to high sand content and low clay content increased the likelihood of abrasion, while the less were in Łeba, Sandomierz, Racibórz and Jelenia Góra (19.59, 21.307, 25.14,25.28 MJ mm ha-1 year-1) respectively. The rainfall effect more on polish soil thanks to continuing mainly sand and silt texture with small percentages of clay.

Key words: Polish soils, Rainfall erosion.

1 Introduction

Climate is one of the major influences on types and rates of erosion processes, both by water and wind. Rainfall is a major control on river sediment yield[1,2] and rates of land sliding [3]. Climate change can be reflected in soil loss and erosion[4]. Soil erosion also has an impact on ecosystem services such as water quality and quantity, biodiversity, agricultural productivity and recreational activities [5].

The Poland climate is continental, with very cold winters, often below freezing and warm summers temperature varies from 6.0 to 8.5°C [6,7], an increase in summer maximum air temperature of about 0.4 °C per 10 years [8], with average long-term precipitation sum oscillates around (600mm) from (1971-2000) [9].

Poland soils were covered with diluvial, alluvial and eolian deposits from interglacial periods but also with periglacial, organic and, locally, alluvial Holocene deposits. Bedrocks of the vast majority of Poland’s soils are various types of Pleistocene post-glacial deposits (of which the most important glacial till, fluvioglacial and eolian formations), characterized by the high variation of basic features: mineralogical composition, grain size distribution, and arrangement of horizons. An important the part is played by alluvial formations from contemporary rivers and bog and post-bog soils built from organogenic formations [10], an interesting aspect is the resistance of rocks to weathering, which contributes to the diversification of soil cover in the mountain areas [10].

High mountains are built from solid magmatic and metamorphic formations, whereas low mountains were formed from deposit structures called flysch (clastic rocks from the Cretaceous and Tertiary periods, mostly schists, sandstones, siltstones, and conglomerates. Taking into account the criterion of granulometric composition of bedrocks, the Polish soil resources are gravels and sands made of various origins constitute nearly 46% of all soil formations, soils built of clays – about 25.5% and soils made up of silts – nearly 8%. The remaining are soils formed from alluvial deposits (about 5%), organogenic structures (8.5%), carbonate rocks (approx.1%) and massive rocks of various origins (about 6%) [11].

The precipitation in Poland related to cyclones moving from the Mediterranean to East-Central Europe (Mediterranean Cyclonal Precipitation–MCP). Average daily sum of MCP constitutes approximately 150% of daily amount of all precipitation in Poland. In the years(1958–2008),the mean annual MCP was characterized by a significant decreasing trend - the MCP sum reduced by 29 mm,42% of its multiannual value [12].

The cold climate in Poland and snow caused snow thaw soil erosion due to freezing soil in cold period, in which water is
extracted from soil aggregates to form small crystals around them, in addition, a considerable quantity of water rises from lower horizons in to the freezing zone. The ice crystals as they form partially destroy the soil aggregation that when thaw come a mass of fine soil particles is released. Disaggregation and oversaturation increase water on soil surface, also freezing increase the erodibility of the soil during the spring is the greatly reduced infiltration rate of snow water into the deeper layers and erosion losses caused by snow water generally show losses increase with soil permeability, while rainfall and its downpour is less damage than snow-water depend on its total quantity and its intensity and snow thaw to produce runoff [13].

In Poland, three levels of urgency of anti-erosion prevention are in use [14]:

A. Very urgent erosion control—occurs when over 25 % of the arable land of the administrative unit faces an average or higher erosion risk,
B. Urgent erosion control—occurs when 10–25 % of the arable land of the administrative unit faces an average or higher erosion risk,
C. Less urgent erosion control—occurs when up to 10 % of the arable land of the administrative unit faces an average or higher erosion risk.

2 Methodology

In Poland, mean monthly, seasonally and annually values of rainfall collected from Institute of Meteorology and Water Management, National Research Institute [15] to study strongly erosion precipitation by equation (1) of rainfall erosion)[16],

\[ R = \sum_{i=1}^{12} 1.735 \times 10^{1.5 \times \log_{10}(P_i/4)} - 0.018 \]  

R is the rainfall erosion (MJ mm ha\(^{-1}\) h\(^{-1}\) yr\(^{-1}\)),
P\(_i\) is the monthly rainfall (mm),
P is the annual rainfall totals (mm).

3 Results and Discussion

The highest Rainfall erosion in Polish cities were in Kasprowy Wierch and Śnieżka (1722.4, 579.59 MJ mm ha\(^{-1}\) year\(^{-1}\)) respectively, while the less were in Leba, Sandomierz, Racibórz and Jelenia Góra (19.59, 21.307, 25.14, 25.28 MJ mm ha\(^{-1}\) year\(^{-1}\)) respectively, (Table 1).The increase in mean annual precipitation was linked to changes in the soil properties with indicators of soil degradation increasing with lower levels of rainfall. The status of the soil was better in wet areas and worse in drier areas. In wet environments, with 950-1100 mm of annual rain, biotic factors, such as the amount of vegetation and organic matter, play the greatest role in maintaining good soil status and preventing erosion. In sub-humid environments, with 650-950 mm of annual rain, biotic factors were also important but so too was the soil texture (high sand content and low clay content increased the likelihood of erosion). In dry soils, with 450-550 mm per year, there was less vegetation and more unprotected soil so the condition was mediated by soil moisture and also by soil texture with again the sand content increases the likelihood of erosion.

Finally, in the semi-arid and arid regions, where rainfall is between 250-350 mm per year, vegetation is of a specific type that needs little water, such as strawflower and cottonweed. This vegetation produces low levels of organic matter within the soil and therefore the soil condition is more closely linked to abiotic properties. High levels of sand content increase the likelihood of erosion but so do high levels of clay since, due to lack of vegetation, there will be crusting of the clay surface which increases erosion [17].

On the other hand, high-intensity rainfall events, especially in the dry areas, will increase runoff and soil erosion [18]. Besides that, if the rain is acidic, Soils containing calcium and limestone are more able to neutralize sulphuric and nitric acid depositions than a thin layer of sand or gravel with a granite base. If the soil is rich in limestone or if the underlying bedrock is either composed of limestone or marble, then the acid precipitation could also be neutralized. This is because limestone and marble are more alkaline (basic) and produce a better pH when dissolved in water. The higher pH of those materials dissolved in water offsets or buffers the acidity of the rainwater producing a more neutral pH. The emission of acidic gases Sox and NOx lead to acid rainfall and cause a new problems, acid deposition[19].
Table 1: Rainfall erosion Polish soils.

| City              | Annual Rainoff | Rainfall erosion (MJ mm ha⁻¹ year⁻¹) | City              | Annual Rainoff | Rainfall erosion (MJ mm ha⁻¹ year⁻¹) |
|-------------------|----------------|--------------------------------------|-------------------|----------------|--------------------------------------|
| Bielsko-Biała     | 109.27         | 29.64                                | Gorzów Wielkopolski| 114.6          | 35.89                                |
| Zakopane          | 77.53          | 31.78                                | Poznań            | 115.06         | 37.31                                |
| Kasprowy Wierch   | 4.7            | 1722.4                               | Koło              | 106.53         | 28.89                                |
| Nowy Sącz         | 108.81         | 30.824                               | Płock             | 103.96         | 27.612                               |
| Krosno            | 106.072        | 31.644                               | Warszawa          | 111.22         | 37.6                                 |
| Lesko             | 127.709        | 29.172                               | Siedlce           | 101.19         | 31.93                                |
| Jelenia Góra      | 97.854         | 25.28                                | Terespol          | 102.3          | 31.01                                |
| Śnieżka           | 20             | 579.59                               | Świnioujście      | 100.109        | 27.37                                |
| Kłodzko           | 99.98          | 30.55                                | Szczecin          | 116.08         | 33.9                                 |
| Opole             | 117.08         | 28.407                               | Piła              | 106.16         | 25.7                                 |
| Racibórz          | 104.136        | 25.147                               | Chojnice          | 100.32         | 31.07                                |
| Katowice          | 109.88         | 35.79                                | Toruń             | 107.81         | 35.96                                |
| Kraków-Balice     | 107.44         | 34.988                               | Mława             | 98.02          | 35.87                                |
| Kielce-Suków      | 101.24         | 36.584                               | Olsztyn           | 97.92          | 34.39                                |
| Tarnów            | 114.669        | 33.769                               | Mikołajki         | 97.55          | 33.86                                |
| Sandomierz        | 101.318        | 21.307                               | Białystok        | 92.1           | 28.77                                |
| Rzeszów-Jasionka  | 110.2          | 38.39                                | Koszalin          | 107.28         | 27.45                                |
| Zielona Góra      | 113.93         | 36.043                               | Ustka             | 107.66         | 28.626                               |
| Legnica           | 115.66         | 28.633                               | Leba              | 102.63         | 19.59                                |
| Leszno            | 112.43         | 31.83                                | Hel               | 107.109        | 26.66                                |
| Wrocław           | 109.8          | 38.535                               | Gdański           | 107.836        | 25.54                                |
| Kalisz            | 121.59         | 30.35                                | Elblag            | 100.86         | 29.769                               |
| Wieluń            | 109.69         | 28.37                                | Kętrzyn          | 98.94          | 30.991                               |
| Łódź              | 107.74         | 31.26                                | Suwałki           | 87.918         | 28.747                               |
| Sulejów           | 98.67          | 26.82                                | Gorzów Wielkopolski| 114.6        | 35.89                                |
| Kożelince         | 106.23         | 34.21                                | Poznań            | 115.06         | 37.31                                |
| Lublin-Radawiec   | 101.536        | 27.056                               | Koło              | 106.53         | 28.89                                |
| Włodawa           | 102.35         | 34.01                                | Płock             | 103.96         | 27.612                               |
| Słubice           | 115.71         | 28.68                                | Warszawa          | 111.22         | 37.6                                 |
| Siedlce           | 101.19         | 31.93                                |                   |                |                                      |

4 Conclusion

The highest Rainfall erosivity in Polish cities were in Kasprowy Wierch and Śnieżka (1722.4 , 579.59 MJ mm ha⁻¹ year⁻¹) respectively. Due to high sand content and low clay content increased the likelihood of erosion, while the less were in Leba, Sandomierz, Racibórz and Jelenia Góra (19.59, 21.307, 25.14, 25.28 595 MJ mm ha⁻¹ year⁻¹) respectively. The rainfall effect more on polish soil due to continue mainly sand and silty texture with small percentages of clay.

References
1. Hicks, D.M., Hill J. and Shankar U., 1996. Variation of suspended sediment yields around New Zealand: the relative importance of rainfall and geology. Erosion and sediment yield: global and regional perspectives, IAHS Publication, 236, 149–156.
2. Hicks D.M, Shankar U, McKerchar A.I, Basher L., Jessen M., Lynn I. and Page M. 2011. Suspended sediment yields from New Zealand rivers. Journal of Hydrology (NZ), 50, 81–142.
3. Glade, T., 2000. Modelling landslide-triggering rainfall in different regions of New Zealand—the soil water status model. Zeitschrift für Geomorphologie Supplementband, 122, 63–84.
4. Farrell P., Abatzoglou J., and Brooks E. 2015. The impact of climate change on soil erosion. Regional Approaches to Climate Change for Pacific Northwest Agriculture: Climate Science Northwest Farmers Can Use: REACCH Annual Report Year 4, 70–71.
5. Pimentel D., Harvey C., Resosudarmo P., Sinclair K., Kurz D., McNair M., Crist S., Shpirtz L., Fitton L. and Blair R. 1995. *Environmental and economic costs of soil erosion and conservation benefits*. *Science*, New series, *267* (5201), 1117-1123.

6. Przybyłak R., Majorowicz J., Wójcik G., Zielski A., Chor W., Marciniak K., Nowosad W., Olinski P. and Syta K. 2005. *Temperature changes in Poland from the 16th to the 20th centuries.* “Int J Climatol., *25*(6), 773–791.

7. Wypych A., Sulikowska A., Ustrnul Z. and Czekierda D. 2017. *Temporal Variability of Summer Temperature Extremes in Poland. Atmosphere* — Open Access Journal. *8* (51), 1-16.

8. Rymuza K., Radzka E. and Lenartowicz T. 2015. *Effect of weather conditions on early potato yields in eastcentral Poland*. Communcations in biometry and crop science, *10*(2), 65–72.

9. Jarosińska E. 2016. *Local flooding in the Usa, Europe, and Poland — An Overview Of Strategies And Actions In Face Of Climate Change And Urbanisation. Infrastruktura I Ekologia Terenów Wiejskich Infrastructure And Ecology Of Rural Areas. Nr iii/1/2016*, Polska Akademia Nauk, Oddział W Krakowie, S., 801–821.

10. Bednarek R., Dziadowiec H., Pokojska U. and Prusinkiewicz Z. 2004. *Ecological-soil Scientific Research (Badania ekologiczno-gleboznawcze)*, PWN, Warszawa, 113–246.

11. Siebielec G., Smreczak B., Klimkowicz-Pawlas A., Maliszewska-Kordybach B., Terelak J., Koza P., Hryńczuk B., EySiak M., Miturski T., Gać Zka R. and Suszek B. 2012. *Monitoring of soil chemistry in Poland 2010-2012. Siebielec G. Iung Pib, Puławy*, 202.

12. DeğirmenDžić J. and KożuchowsKi K. 2015. *Precipitation of the mediterranean origin in poland – its seasonal and long-term variability. Quaestiones geographicae, *34*(1), 37-35.

13. Zachar, D. 1980. *Soil erosion. Development in Soil Science 10*. Chapter 5 Distribution erosion – Asia, *10*, 548.

14. Józefaciuk A. and Józefaciuk Cz. 1992. *Zagrożenie erozją wodną w Polsce. Pamietnik Puławski*, 101 supl.; 23–50.

15. IMGW-PiB. 2017. *Rainfall and temperature 2006-2016. Poland*.

16. Al-Abadi, A,M,A, Hussein, B., Ghalib, H.B. and AlQurnawi, W.S. 2016. *Estimation Of Soil Erosion In Northern Kirkuk Governorate*, Iraq Using Rusle, Remote Sensing And Gis. Carpathian Journal of Earth and Environmental Sciences, *11*(1), 153 – 166.

17. Ruiz-Sinoga, J.D. and Romero Diaz, A. 2010. *Soil degradation factors along a Mediterranean pluviometric gradient in Southern Spain*. *Geomorphology*, *118*, 359-368.

18. Ziadat, FM, and Taimeh, AY. 2013. *Effect of rainfall intensity, slope, land use and antecedent soil moisture on soil erosion in an arid environment*. *Land Degradation & Development, 24*(6), 582–590.

19. Mossa, N.Kh. and Badora A. 2018. *Rainfall erosivity effect on Iraqi and Polish soils*, *International Journal of Scientific and Engineering Research(IJSER), Volume 9, Issue 4, pp:494-497.*