Characterization of Rainfall Regime in Bucharest (2009-2015)

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Abstract: *This paper analyzes rainfall in Bucharest in 2009-2015. There are analyzed monthly average amounts of precipitation, distribution of quantities, seasonal rainfall, annual rainfall regime, the number of days with rainfall, the annual number of days with rainfall between certain limits, precipitation in the hot semester, and precipitation in the cold semester.*

Keywords: *Seasonal rainfall, monthly average amounts, half-yearly, yearly*

1. Introduction

Ecometrici climatic indices are formulas for climatic suitability, taking into account the actual amounts of key climate factors.
Monthly precipitation values are different depending on the circulation of air masses, altitude, slope orientation of landforms, local conditions.
Rainfall is an important meteorological parameter in assessing air quality by cleaning air in the lower layer, where industrial activities take place [1]. Knowing precipitation scheme was annual and multiannual, the variability over time, frequency form and intensity with falling presents practical interest, application and theory to provide usable reserves of soil moisture as a source of food rivers and prevent and combat the negative effects.
The energy that contain rainfall is divided into two, the kinetic energy of rainfall that is their strength impactor with direct role in the destruction of aggregates from soil and their energy potential, energy runoff on slopes and whites, with important role in detachment and transport parts of broken rock in its path [2].
Bucharest territorial sat on the periphery of anticyclonic influences aisatic and cyclone ocean and Mediterranean peculiar frontal and convective precipitation.
According rainfall from weather stations on the territory of Bucharest that the annual average rainfall varies between 600-700 mm annually, where the amount of aerosols is higher due to industrialization [1].
During recording a maximum rainfall in May-June. Heavy precipitation falling during the warm season of the year due to advection of moist air masses coming from the Atlantic Ocean, and thermo-convective processes that produce torrential rains sometimes accompanied by hail. Heavy rains occur over Bucharest because thermal convection is stronger. High frequency of rainfall in warm semester continental climate highlights the character of this country. They are generated by a high moisture air of intense activity and convection heat, which stimulates the development of clouds and rainfall intensification [1].

2. Results and discussion

Rainfall was recorded by the weather station at the Biotechnical Faculty of Engineering of the UPB, analyzed interval is 2009, 2010, 2011, 2012, 2013, 2014, 2015. And the comparison was made with data from the years 1961-1990 rainfall data ANMH site.
The least amount of rainfall between January and March due to the predominance anticyclone regime, preventing the development of thermal convection, the driest month of February. Starting in March, the precipitation increases progressively from May to June, for an annual maximum rainfall (197.4 mm). Rainfall this month are generated by the high frequency of cyclones ocean.

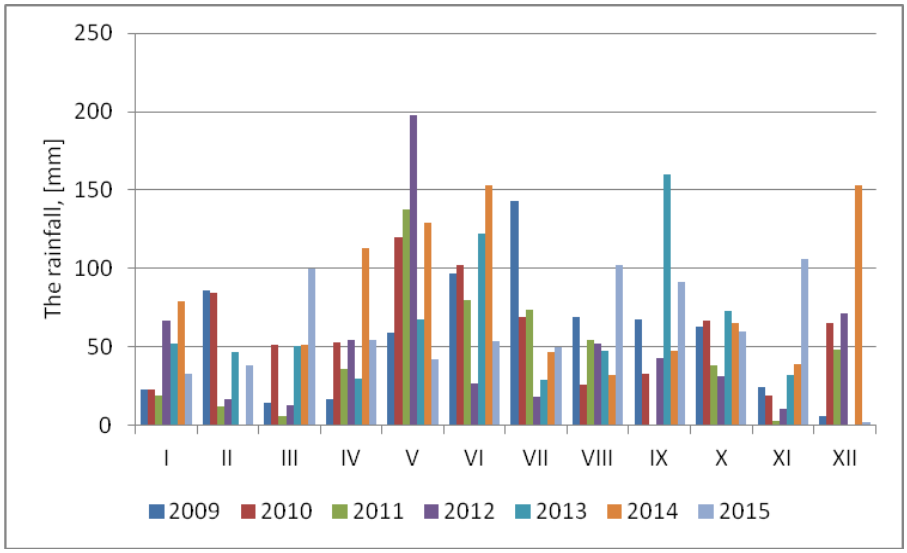

Fig. 1. The graphical representation of the average amount of rainfall in the period 2009-2015 compared with 1961-1990

The average amount of rainfall registered in Bucharest in 2009 was within normal limits (658.6 mm) compared to the period 1961 to 1990 (596.2 mm).
In the first months of the year (January, February, and March) precipitation likely prevail front; the local is very low, with small fluctuations from month to month. In January masses of air from the anticyclone Eurasian have a high frequency, coming cold, common cold, dry in their way, there aren't any obstacles orographic major and systems cloudy related fronts cyclones Mediterranean are routed mainly over the Pannonian Plain, orographic barrier east of the eastern Carpathians, rarely failing to get all these lead to the recording of very small average amounts of precipitation.
Since April, rainfall almost doubled. Between May and June, the amount of rainfall recorded a sharp rise and continues to rise until July. In July, the work cyclone intensifies the northern outskirts of Ridge and the anticyclone of the Azores extended to the south of Romania, bringing air masses wet and unstable and convection heat is considered as a supplement moisture of brought the movement west on stretches of ocean in western Europe. Higher levels of rainfall in the June-July is due primarily produce thermal convection (besides processes Front), which causes strong rain showers.
In August, September, rainfall is decreasing because of lower thermal convection with temperature decrease. In October, November and December convection heat disappears and precipitation are caused not only by cold advection of air masses, coming from the continental north and east, resulting in very low amounts and largely solid. These variations have a normal progression, ascending in the first half to record maximum in May, after which values decrease progressively until December, so in January to register the minimum [1].
The average amount of rainfall in Bucharest in 2009 (669 mm) exceeded the climatological normal (596.2 mm) with a positive deviation of 3.12%. The annual amount of precipitation in 2010 in Bucharest was 713 mm below the climatological norm (596.2 mm) with a positive deviation of 19.59%.
Overtaking the highest of standards climate monthly quantities of precipitation in Bucharest occurred in May 2012 (exceeded normal climatological a positive drift of 181.20%). The annual amount of precipitation on average in 2011 in Bucharest was 507.8 mm below the climatological norm (596.2 mm) with a negative deviation (-14.83%) due to the poor rainfall in most months except the months: May (with misconduct positive 95.73% compared to normal climatological), June (with a positive drift of 3.10% compared to the climatological normal) in July (with a positive drift of 15.40% compared to normal climatological), October (with a positive drift of 20.50% compared to climatological normal) and December (with a positive deviation of 10.85% compared to the climatological normal). In the other eight months of the year deviations were negative in the months: January rainfall was 52.02% lower than the climatological normal April rainfall was 21.74% lower than the climatological normal August rainfall was with 7.03% less than normal largest

deficits were registered in March (with a deviation of 84.82% in September (100% rainfall lower than normal climatological), November (94.26%).
Precipitation recorded in Bucharest in 2012 under normal climatological were in the months of February (16.8 mm by 53.59% lower than the climatological normal), March (5.8 mm to 38.2 mm by 65.45 % lower than the climatological normal), June (37.6 mm to 77.4 mm by 51.42% lower than the climatological normal), July (28.3 mm versus 64.3 mm by 55.99% lower than the climatological normal), August (38.3 mm to 58.3 slightly deficient rainfall with 34.31% lower than normal climatological), November (low rainfall quantitatively 10.3 mm to 48.8 mm by 78.89% lower than the climatological normal processes of vegetation species autumn were slowed. the fruit trees and vines and continued yellowing and leaf fall, farm work in the field, crop residues release land, plowing, were made in good condition).
The annual amount of precipitation in Bucharest in 2014 was 953 mm beyond the standard climatological normal (1961-1990) (596.2 mm), with 59.85%. Deviations were positive in the months: March (33.77%), April (145.65%), May (83.90%), June (97.67%), July (1.09 %), September (12.32%), October (103.79 %), August (1.20 %), December (253.12%) deviations were negative in: January (98.74%), February (98.90%), July (26.75%), August (26.6%), November (20.49%), the annual amount of precipitation in Bucharest in 2015 was 730.8 mm beyond the standard climatological normal (1961-1990) (596.2 mm), with 22.58% (Figure 1 and table 1).

TABLE 1: Deviations from the years 2009-2015 (%)

	Deviations from the years 2009-2015 rainfall against the normal climatological (1961-1990) (%)					
	I	**II**	**III**	**IV**	**V**	**VI**
2009	-52.02	0.55	-47.64	-63.48	-15.38	25.32
2010	-42.42	134.25	33.51	14.35	70.37	32.30
2011	-52.02	-65.75	-84.82	-21.74	95.73	3.10
2012	68.18	-53.59	-65.45	17.83	181.20	-51.42
2013	51.52	35.36	70.16	-35.87	23.93	67.96
2014	98.74	-98.90	33.77	145.65	83.90	97.67
2015	-17.68	6.08	161.52	19.13	-30.20%	-22.48%

TABLE 1: Deviations from the years 2009-2015 (%) *(continued)*

	Deviations from the years 2009-2015 rainfall against the normal climatological (1961-1990) (%)						
	VII	**VIII**	**IX**	**X**	**XI**	**XII**	**annual**
2009	122.40	18.70	60.19	98.74	-50.41	-87.07	3.12
2010	7.62	-55.06	-21.33	110.73	-60.25	50.12	19.59
2011	15.40	-7.03	-100.00	20.50	-94.26	10.85	-14.83
2012	-55.99	-34.31	1.18	-22.08	-78.89	64.67	0.87
2013	-56.45	2.92	110.90	149.21	-13.93	-99.31	-20.56
2014	1.09	1.20	12.32	103.79	-20.49	253.12	59.85
2015	-6.69%	50.60%	100.00%	90.22%	108.40%	-95.61%	22.58%

Seasonal precipitation amounts distribution

Seasons as a feature of temperate continental climate, summer fall the highest amounts of rainfall (16% - 46%) and winter fewest (9.93% - 25.76%) of the year. Spring (16.92% - 44.09%) and autumn (16.61% -35.56%) intermediate amounts of rainfall recorded compared to the other two seasons (Table 2).
Annually there are two maximum and two minimum rainfalls. The major peak in May-June occurs as a result of increased thermal convection and the deepening work polar front and the secondary November-December due to the development of Mediterranean cyclones that bypass the country from the west and southwest. Lows rainfall is related to drought periods from late winter-early

spring and the late summer-early autumn. In the summer season there are high amounts of rainfall compared to the winter season where there was a decrease theirs, but increases in summer occurs generally in the form of rain, which often cause flooding.

TABLE 2: The amount of rainfall in spring multiannual period 2009-2015

The analyzed period	Winter	percentage of the annual average	Spring	percentage of the annual average	Autumn	percentage of the annual average	Summer	percentage of the annual average
2009	81.4	12.17%	113.2	16.92%	154.8	23.14%	309.4	46.25%
2010	172.6	24.21%	223.2	31.31%	119.4	16.75%	197.8	27.75%
2011	79.4	15.64%	179.2	35.29%	118.7	23.38%	208.2	41.00%
2012	154.7	25.76%	264.8	44.09%	77.7	12.94%	97.1	16.17%
2013	109.3	15.39%	181.5	25.55%	210	29.56%	199.1	28.03%
2014	232	24.69%	293.2	32.30%	150.8	16.61%	231.8	25.53%
2015	72.9	9.93%	203.7	27.75%	246.4	33.56%	206.3	28.10%

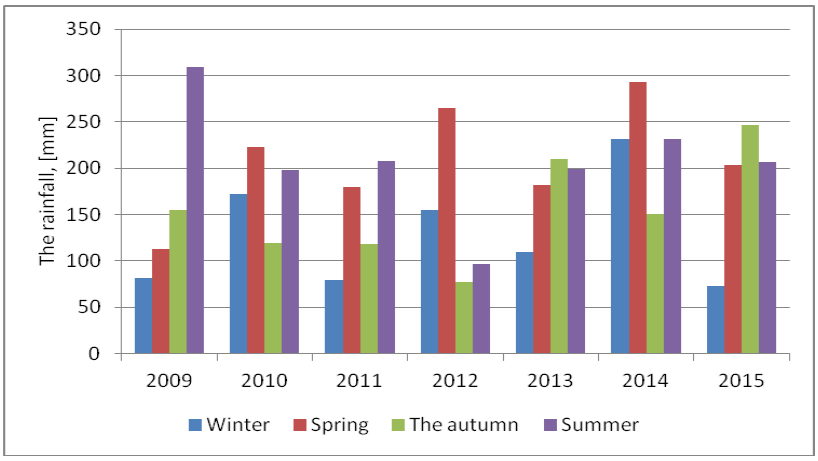

Fig. 2. The amounts of rainfall in the four seasons of the year

The annual rainfall regime in Bucharest between 2009-2015

The annual rainfall regime in Bucharest in the period 2009-2015 compared with 1961-1990 average climatological records a major peak in May, the average amounts of precipitation are over 197.4 mm in 2012, 129.1 mm in 2014. In May fall in the range 2009-2015, 778.9 mm rainfall 659.8 mm compared to June. And July is characterized by a rich rainfall in third place after May, June and the annual minimum in November (239.2 mm) and February (237.8 mm).

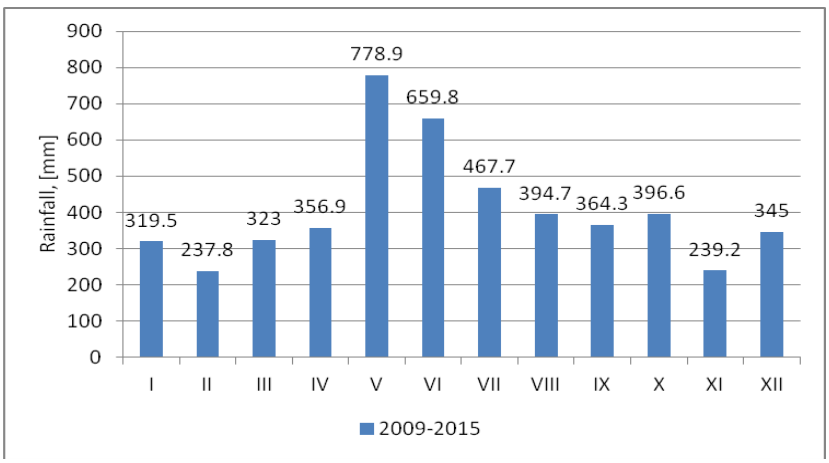

Fig. 3. Distribution yearly rainfall in Bucharest between 2009-2015

The number of days with precipitation in Bucharest between 2009-2015

For the analysis of rainfall days were used daily rainfall data recorded by the weather station at the Biotechnical Faculty of Engineering U.P.B. on 2009-2015.
The average annual number of days with precipitation is over 100 in four years, so raining about 3-3.5 months of the year (2010, 2013, 2014, 2015), and the average monthly number of days with precipitation has a maximum in May, 87 days. The average monthly number of days with precipitation has a minimum in August, 33 days (Figure 3).

The annual number of days with rainfall between certain limits

We calculated for years 2009, 2010, 2011, 2012, 2013, 2014, 2015, the annual number of days with precipitation amounts, it appears that precipitation ≥ 0.1 mm in Bucharest are 477 days, decreasing as threshold of increase amounts to 271 days if ≥ 0.5 mm rainfall; 199 days for those that ≥ 1.0 mm rainfall; 188 days for precipitation ≥ 2.0 mm; 98 days if ≥ 5.0 mm rainfall; 48 days in case of rainfall diurnal ≥ 10.0 mm, 9 days when daytime precipitation ≥ 20 mm and 4 days with rainfall amounts ≥ 30 mm.
On the same day rainfall was 0.1 mm and 1.0 mm and 2.0 mm and. In Bucharest prevails ≥ 0.1 mm precipitation.

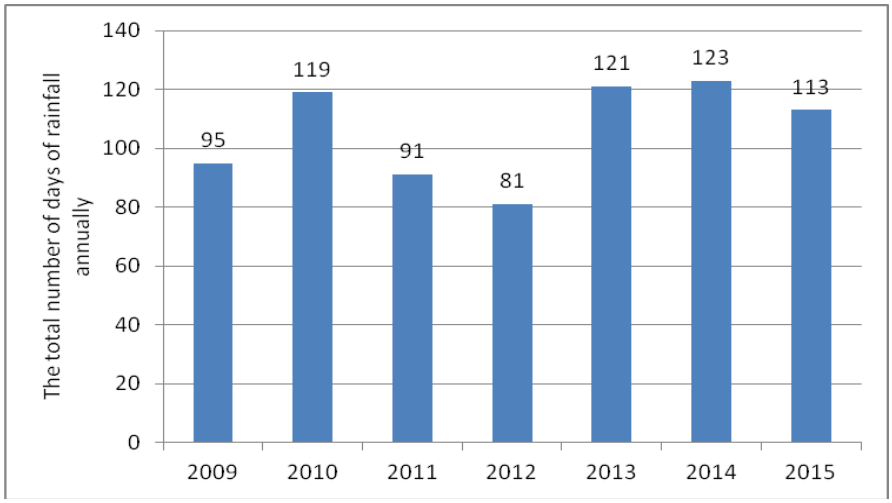

Fig. 4. The total number of days of rainfall annually

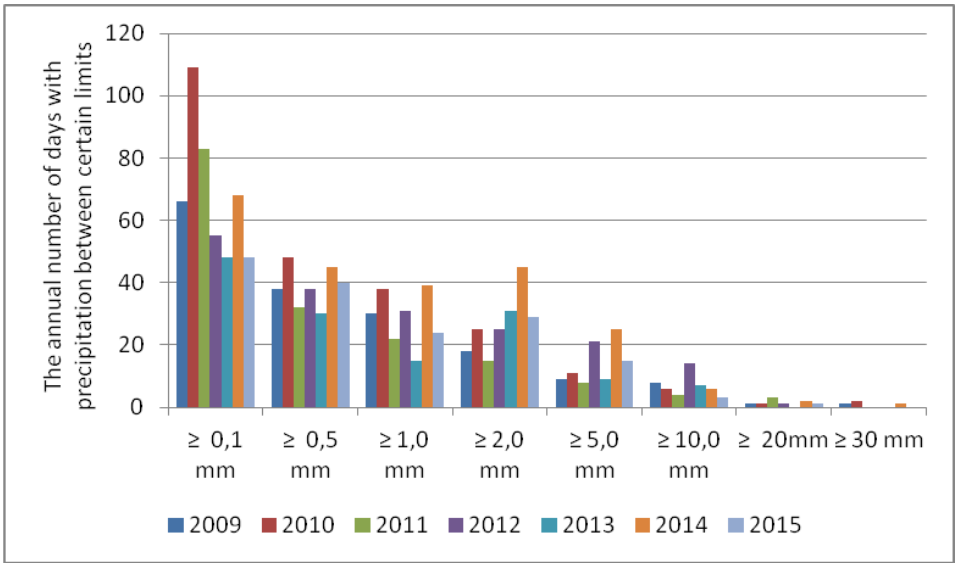

Fig. 5. The annual number of days with precipitation between certain limits in Bucharest (2009-2015)

Precipitation in the warm semester

Precipitation during the period of maximum consumption is the amount of precipitation that corresponds to the interval from May to September, when registered the highest thermal values. Generally, this period is characterized by long periods of drought and intensive [4].
Precipitation in the warm semester are between 381.6 mm (2011) and 566.5 mm (2014).
The average amounts of precipitation in the warm half of the year (months IV-IX) in the city of Bucharest in 2009-2015 were calculated based on weather data recorded by the weather station at the Faculty of Biotechnical Systems Engineering from Polytechnic University of Bucharest, their values are given in table 5. it is noted that the highest amounts of rainfall were recorded in June 2014 (153 mm).
In terms of precipitation, June 2014 was rich in rainfall, which amounted on average to the level of Bucharest an amount of 153.5 mm, compared to the 1961-1990 climatological reference, the average is 77, 4 mm.
In June, on almost the whole country recorded the highest amounts of rainfall throughout the year [3].
Quantities significant rainfall Specific June is mainly due to intense activity of Ridge and the Azores High, extended south of Romania, which brings air masses wet oceanic and unstable, which on contact with air tropical covering and area of our country causes production of precipitation particularly abundant. They may be the result of crossing the area examined by weather fronts (or their peripheries) or local factors that may cause considerable vertical development generating rainfall. Heavy rains falling in Romania are dependent on elevation, landform, Carpathian orographic blocking role to advection of moist air to solar radiation as well as other local conditions and time.
The average intensity of heavy rains is the main characteristic of them; it gradually decreases with altitude up to 3 mm in high mountain regions. A torrential rain if its intensity is average
It is 0.2 mm / min and the average intensity excessive rain if it is 0.45 mm / min over a period of 121-180 minutes [7].
Below in figure 6 are presented precipitation analysis specific ecological factors. It is characterized during water accumulation in a biologically active horizon (X-III) or maximum biological activity period (IV-IX).
For spontaneous vegetation, these low precipitation can be an indicator illuminating in terms of the character and xeromezofite xerophit vegetation that grows in all areas of the steppe.
Moisture deficit characteristic of this period, the drying effect of trees and shrubs green spaces, decreasing habitat comfort internally and externally, the rising cost of living.

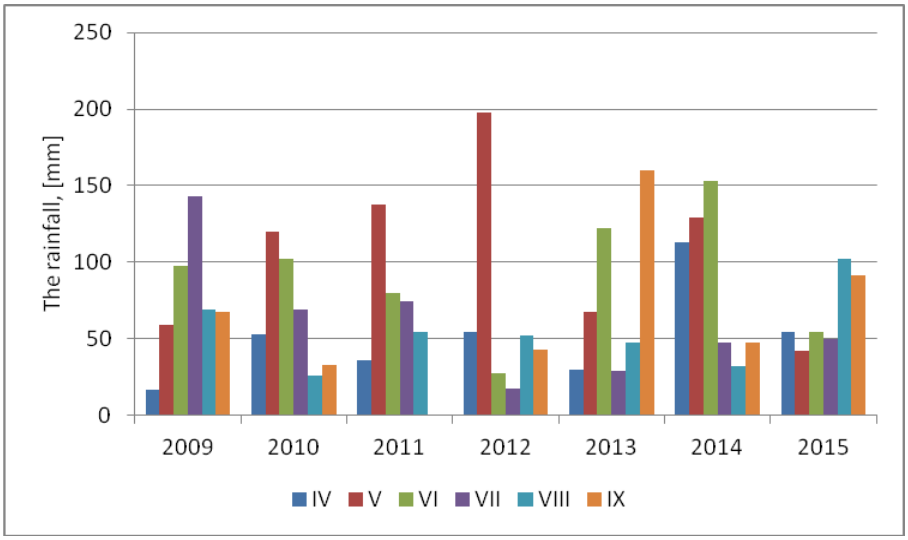

Fig. 6. The amount of rainfall in warm semester in Bucharest, between 2009-2015

Precipitation in the cold semester

In cold fall semester between 205.6 mm (2009) and 334.8 mm (2015).
Precipitation semester cold are less abundant than those recorded in the warm semester of the year due to high-frequency air masses continental cold and dry (with a low water vapor) and because clouds and precipitation convection heat have development lower than in summer. Above our country anticyclone prevailing regime of no rainfall [9].
In January masses of air from the anticyclone Eurasian have a high frequency, coming cold, common cold, dry in their way neinterpunându into any obstacles orographic major and systems cloudy related fronts cyclones Mediterranean are routed mainly over the Pannonian Plain, orographic barrier east of the eastern Carpathians, rarely failing to get all these lead to the recording of very small average amounts of precipitation [9].
October-March period is a period of excess water in the soil, it is necessary accumulation of vegetation structure in the first two phases of the vegetative cycle (germination and sprouting).
High temperatures in this period leading to high levels of actual evapotranspiration. Given and full development of foliage, plants needs are maximized, resulting in depletion of ground water. The amount of rainfall during the cold season of the year is the total amount of water resulting in solid and liquid precipitation. Winter important in terms of rainfall, as it ensures the water reserve in the soil, which is then used during the first phenological phases [4]. The amounts recorded in this period represents approximately 24.85% (cold semester 2011) – 45.85 % (cold semester 2015) of the annual average (Figure 7) are lower than in the first half of the year hot.
These low values illustrate droughts, which occurs due to reduced amounts of rainfall in this period especially important for agriculture because now formed into useful soil water reserve required beginning of the growing season. Limited rainfall and lead to a higher concentration of pollutants in the atmosphere [1].

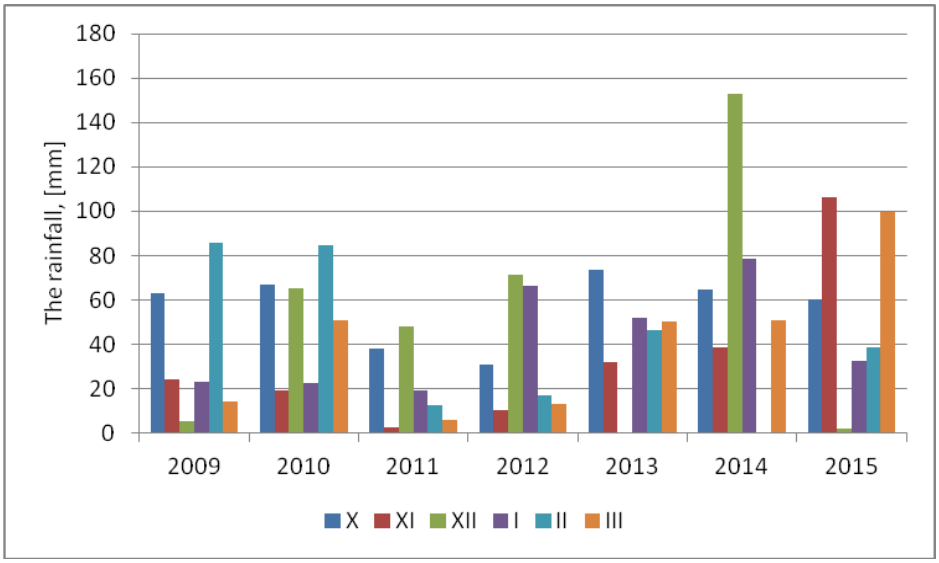

Fig. 7. Showed average values of rainfall semester cold in Bucharest 2009-2015, based on data from the weather station.

3. Conclusions

Cold precipitation semester are less abundant than those recorded in the warm semester of the year. The average annual number of days with precipitation is over 100 in four years, i.e. raining about 3-3.5 months a year, and the average monthly number of days with precipitation has a maximum in May 87 days. The average monthly number of days with precipitation has a minimum in August 33 days.
The annual rainfall regime in Bucharest in the period 2009-2015 compared with 1961-1990 average climatological records a major peak in May, June and July followed by an annual minimum in November, February and March.

Seasons as a feature of temperate continental climate, summer fall the highest amounts of rainfall and lowest in winter of the year. Spring and autumn intermediate amounts of rainfall recorded compared to the other two seasons.
In the summer season there are high amounts of rainfall compared to the winter season where there was a decrease theirs, but increases in summer occurs generally in the form of rain, which often cause flooding.

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