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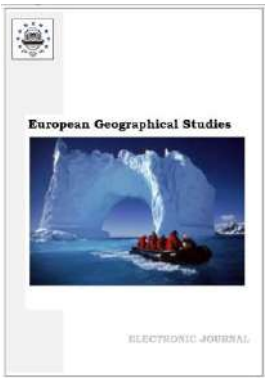

Articles

The Features of the Formation of the Hydrological Regime of Mountain Rivers on the Territory of the Sochi Black Sea Region

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Abstract

The article is devoted to the analysis of the formation of the hydrological regime of the mountain rivers of the Sochi Black Sea region. Due to the peculiarities of the geomorphology and relief of the region, as well as climatic conditions, the main zone of river flow formation is the high-mountain and mid-mountain part of the river basins. Thus, the Mzymta river in the winter period of the hydrological year (from November to March) has a minimum flow, and the average increase in flow is 2 times in the warm season (from April to October). The remaining rivers of the region, due to the predominant rain supply, are characterized by increased runoff in the cold season.

There are analyzed the features of the flow formation along the length using the example of two main rivers of the region that have flow observations (the Mzymta and Sochi rivers). From the graphs of changes in water flow rates and total runoff layers, it was found that the greatest water content of rivers falls on the average flow of the river. At the same time, a third of the length of the rivers, which fall on the low-mountain and low-hilly zones, significantly loses flow to the formation of intra-pebble runoff. The most significant in this regard are the values of the runoff on the Sochi River, which give a zero increase in water consumption from the 15-km estuary part of the basin (58 km^2 is an increase in the catchment area).

Keywords: Sochi Black Sea region, geomorphology of the Caucasus, river network, Mzymta and Sochi river basins, runoff volumes, change in river flow along the length, hydrological regime of rivers.

1. Введение

Рассматриваемая территория в административном отношении характеризуется сложным строением, где фигурируют Сочинский национальный парк, площадь муниципального объединения город Сочи, по административным границам занимает большую часть СНП. Высокогорья принадлежат в основном Кавказскому госзаповеднику и некоторым ООПТ более мелкого значения. Тем не менее в геоэкологическом отношении изучаемая территория представляет единый природный комплекс, и требует единого названия. Такое название нами предложено как сочинское Причерноморье.

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Особенностью региона в гидрологическом отношении является то, что район представляет собой ряд замкнутых речных бассейнов с отчетливо очерченными контурами, внутри которых происходит почти полностью весь процесс круговорота влаги. Осадки, выпадающие в бассейнах рек в виде дождя и снега, частично уходят на испарение и транспирацию, но большей частью возвращаются поверхностным и подземным стоком в Чёрное море.

Из анализа гидрографической сети изучаемого региона следует, всю гидрографическую сеть его можно разделить на три уровня. Первый уровень – бассейны рек, имеющие истоки с хребтов в пределах высокогорного и среднегорного рельефа. Осевое положение, наибольшие высоты и наиболее древние породы соответствуют Главному Кавказскому хребту и его отрогов, который прорезан долинами рек. Главный хребет в пределах Сочинского Причерноморья имеет высоты от 1425 м на горе Лысой до 3257 м на горе Псеашхо. К этому уровню в пределах Сочинского Причерноморья следует отнести 6 рек: Псоу, Мзымта, Сочи, Шахе, Псезуапсе и Аше, Площади их водосборов колеблются от 896 км² (р. Мзымта) до 255 км² (р. Псезуапсе).

Бассейны второго уровня располагаются в пределах среднегорного рельефа, а малые бассейны третьего уровня приурочены к низкогорному рельефу Сочинского Причерноморья.

2. Материалы и методы

На Рисунке 1 представлена схема расположения нескольких хребтов, имеющих водораздельное значение. Так, цепи гор составляют хребты: Главный Кавказский, Водораздельный, Южный Боковой, Ахцу, Ацетукский, Цахвоа, Аишхо, Турьи горы, Алек. К Главному Кавказскому хребту относятся горы: Лысая 1425 м над ур.моря; Грачев Венец 1544 м; Хуко 1900.6 м; Фишт 2867.7 м; Бзыш 2052 м; Пшихашха 2120 м; Малая Чура 2178 м; Чугуш 3238.2 м; Ассара 2631.8 м; Псеашхо 3256.9 м; Скалистая 3157.8 м; Цахвоа 3345.9 м над ур.моря.

Горы верховьев реки Мэымта: и её притоков включают (см.рис.1): 6.Кардывач (2960 *м),* 7. Лоюб (2000 м), 8. Циндышха (3139 м), 9. Пик Смидовича-Акарагварта (3000 м), 9а. Цахвоа (3345), 10. Агепста (3256 м), 11. Псеашхо (3257 м), 12. Чугуш (3238 м), 13. Аибга (2452 м), 14. Ачишхо (2391 м). Горы верховьев реки Сочи: 15. Чура (2250 м над ур. моря), 16. Амуко (1918 м), 17. Хребет Ажск, 18. Иегош, 19. Сахарная.

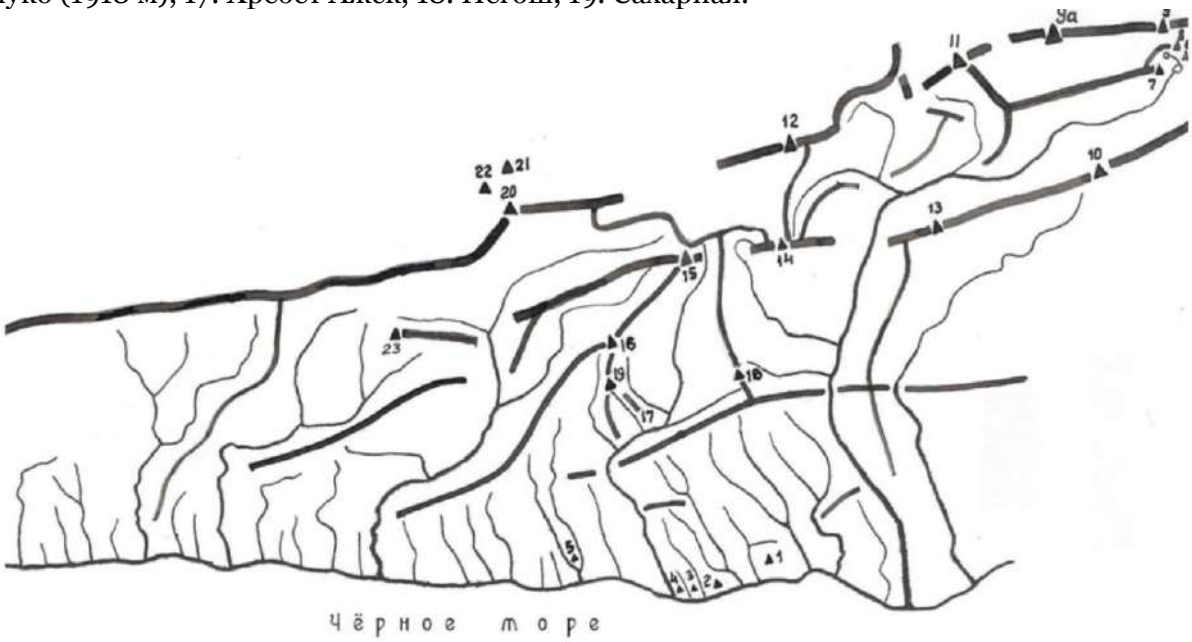

Рис. 1. Схема гор и хребтов Сочинского Причерноморья

В соответствии с высотным расположением каждого водосбора формируется гидрологический режим и питание рек региона. Реки имеют паводочный водный режим,

при этом паводки имеют в основном дождевое и снеговое происхождение. Число паводков составляет в среднем 25-30 в год. Паводки характеризуются кратковременностью (в среднем до 5-6 суток) и большой интенсивностью подъёма уровня воды (от 1-2 до 4-5 м). Руслоформирующие паводки возникают при выпадении интенсивных ливней, превышающих 80 мм и более.

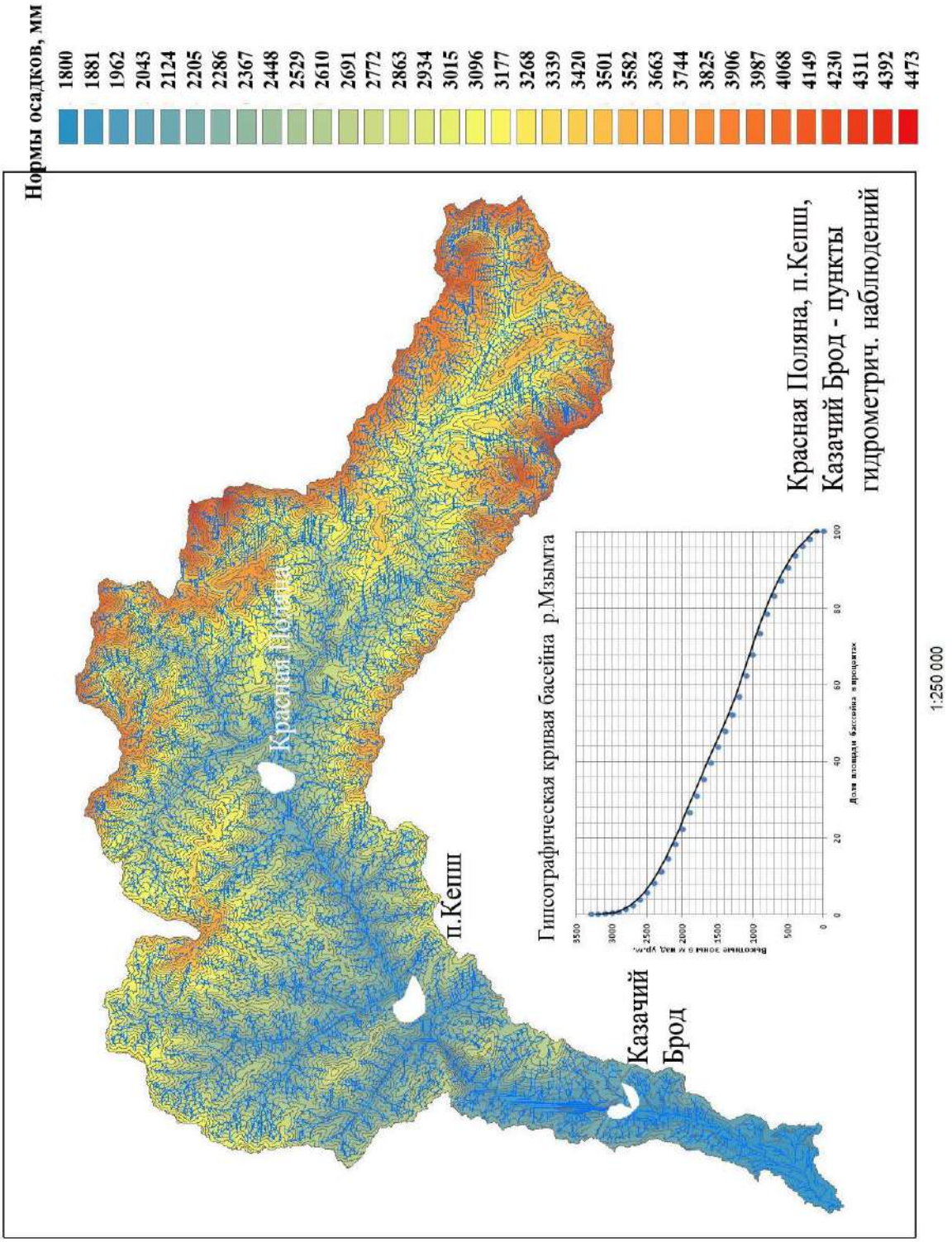

Рис. 2. Карта бассейна реки Мзымта с гипсографической кривой бассейна и распределением норм осадков по высотным зонам.

В качестве примера построения цифровых моделей рельефа бассейнов рек на Рисунках 2 и 3 приведены схемы бассейнов рек Мзымта и Сочи с гипсографическими кривыми (с применением компьютерной программы ARC-GIS).

Бассейны этих рек выбраны, исходя из основной причины – наличия опубликованных данных по стоку реки в двух и более пунктах, расположенных по длине реки. Это дает возможность проанализировать изменение режима и величины речного стока в связи с протеканием от истока к устью.

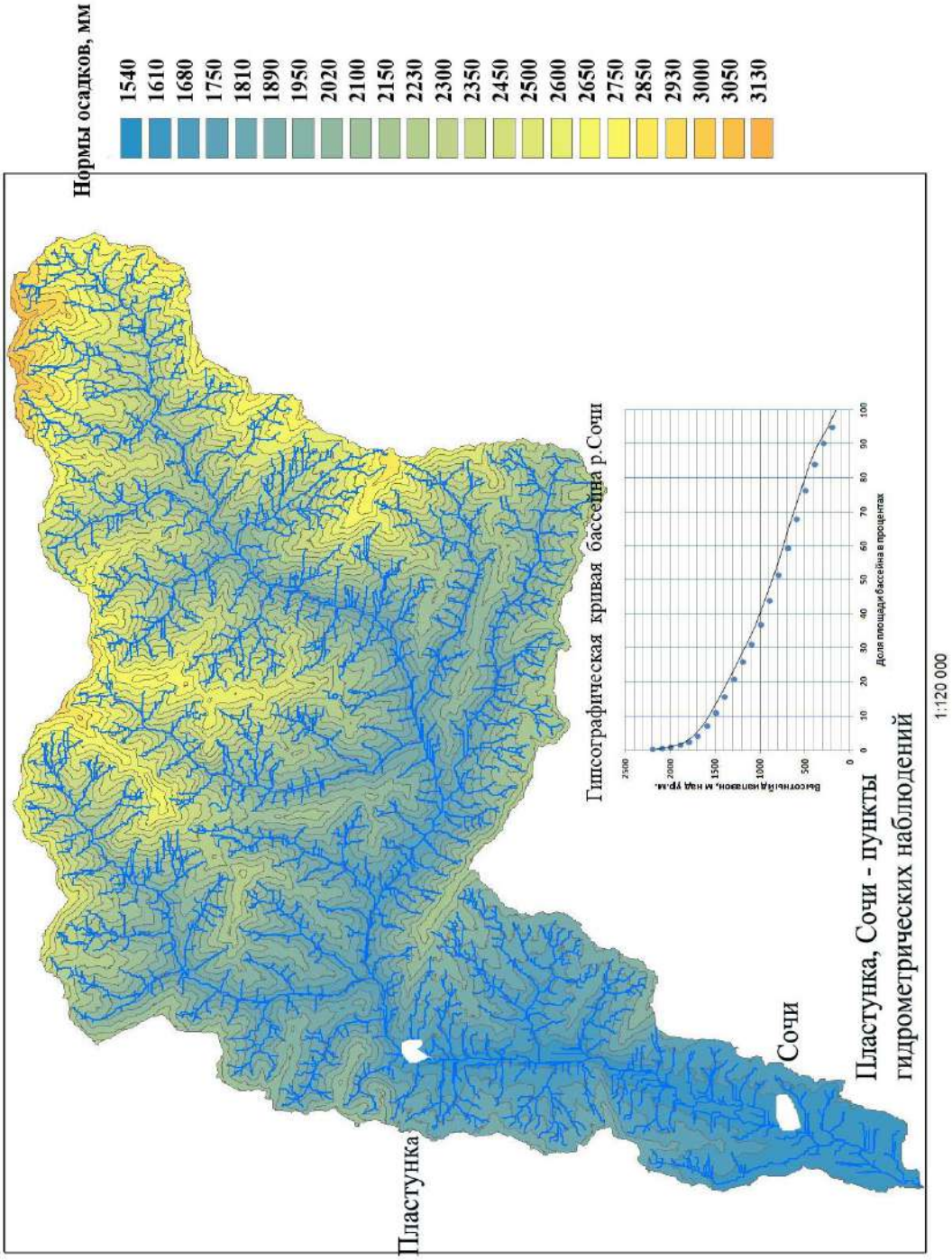

Рис. 3. Карта бассейна реки Сочи с гипсографической кривой бассейна и распределением норм осадков по высотным зонам.

В связи с указанными выше особенностями геоморфологии региона бассейны рек Мзымта и Сочи имеют резко асимметричный вид формы бассейна с основной частью

бассейна в зоне высокогорного и среднегорного рельефа, и коротким узким участком, проходящем в низкогорном рельефе.

Река Мзымта имеет три пункта наблюдений за речным стоком – у пос. Красная Поляна в 41 км от устья, у пос. Кепш – в 30 км от устья, и у пос.Казачий Брод – в 14 км от устья.

Река Сочи имеет долгосрочные наблюдения за речным стоком в двух гидростворах – у с. Пластунка (в 15 км от устья) и у г. Сочи (в 1 км от впадения в море).

В связи с несомненной зависимостью речного поверхностного стока и подруслового внутригалечного стока далее приведен анализ режима подрусловых вод реки Мзымта. По результатам разведки, проведенной Лазаревской гидрогеологической партией, в 1981 г. на Ахштырском участке проанализирован режим пресных подземных вод, располагающихся в расширенной и переуглубленной приустьевой части долины р. Мзымта. Его южная граница проходит в 2,5 км от берега Черного моря, а северной границей служит участок сужения долины в 9 км от устья реки, общая протяженность составляет 6,5 км (Рисунок 4).

Подземные воды в пределах участка приурочены к валунно-гравийно-галечниковым отложениям аллювиального голоценового водоносного горизонта мощностью от 20 до 60 метров, слагающим переуглубленное ложе долины р. Мзымта в ее приустьевой части. С приближением к коренным бортам долины мощность водоносного горизонта постепенно уменьшается до полного выклинивания.

Глубина залегания зеркала грунтовых вод в естественных условиях составляет 1-5 м. Подземные воды аллювиальных отложений представляют собой грунтовый поток, направленный в сторону моря и получающий питание за счет инфильтрации поверхностного стока, атмосферных осадков и в меньшей степени за счет дренирования подземных вод склоновых отложений. Разгрузка их осуществляется в пределах морского шельфа.

В пределах участка подземные воды приурочены к валунно-галечниковым отложениям аллювиального голоценового водоносного горизонта. В плане водоносный горизонт имеет вид полосы с границами, совпадающими с бортами переуглубления долины. Аллювиальные отложения залегают на мощной толще практически безводных отложений палеогена, слагающих коренное ложе и борта долины р. Мзымта.

Глубина залегания грунтовых вод в естественных условиях изменялась от 2,0-2,5 м до 6-7 м и целиком контролировалась изменением площади поперечного сечения аллювиального голоценового водоносного горизонта, увеличиваясь на участках сужения в результате подпора грунтовых вод (Рисунок 4).

Максимальная мощность водоносного горизонта отмечается в южной части участка по тальвегу переуглубления, где по геофизическим данным достигает 44-46 м. На северной границе участка в Ахштырском ущелье мощность водовмещающего аллювия составляет 30-32 м. С приближением к коренным бортам долины мощность водоносного горизонта уменьшается до полного выклинивания.

Питание аллювиального голоценового водоносного горизонта осуществляется главным образом за счет инфильтрации поверхностного стока и атмосферных осадков. В питании аллювиального водоносного горизонта участвуют также подземные воды верхнемеловых отложений, которые в паводковые периоды играют существенную роль в восполнении сработанных за межень эксплуатационных запасов.

В Таблице 1 приведены анализированные данные по расходам воды рек Мзымта и Сочи, осредненные по сезонам (холодному – с ноября по март, теплому – с апреля по октябрь, и в целом за гидрологический год) за периоды параллельных наблюдений на отдельных гидростворах указанных рек.

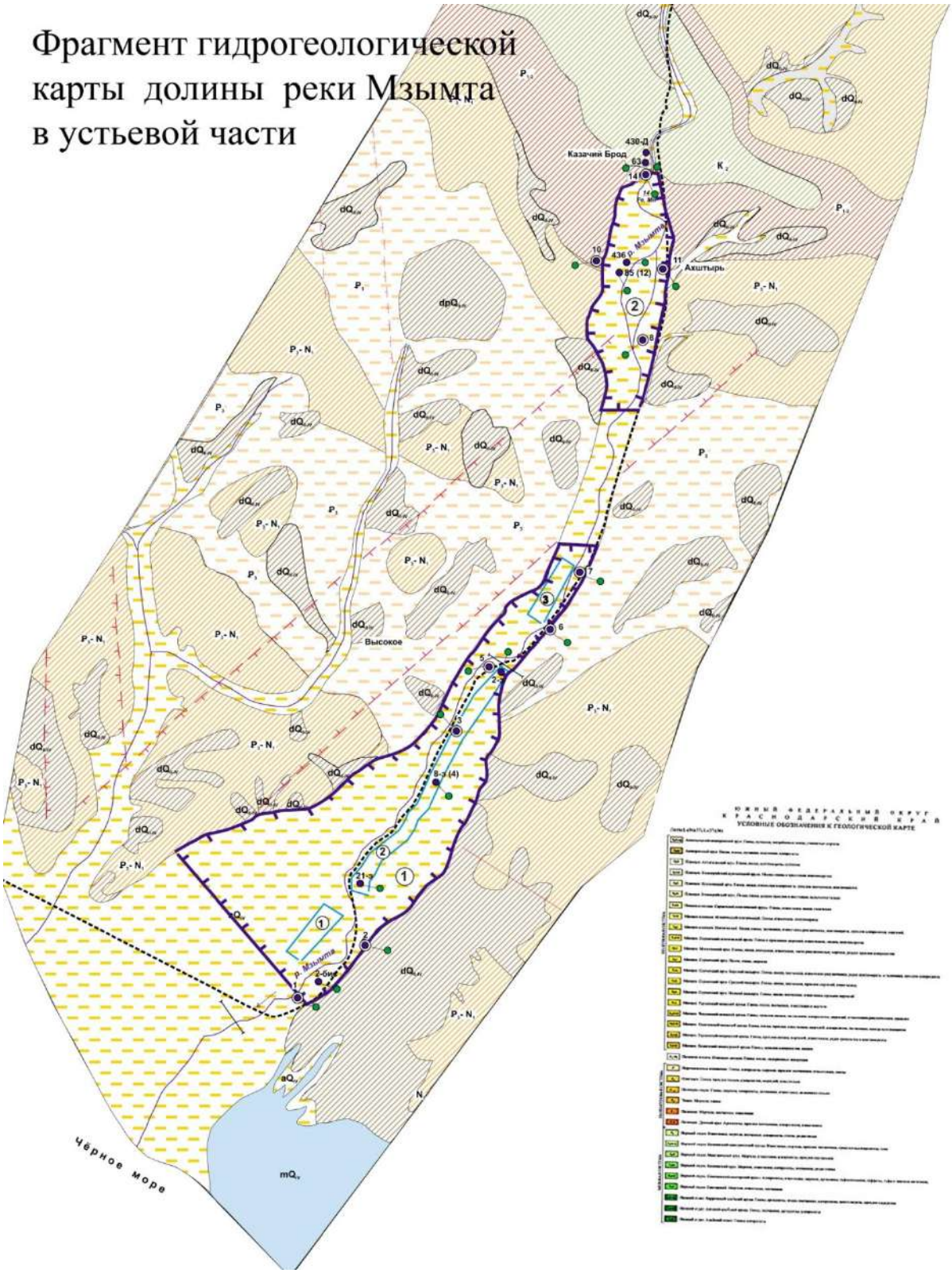

Рис. 4. Схематическая эколого-гидрогеологическая карта нижней части долины реки Мзымта

Автор: Государственное унитарное предприятие « Кубаньгеология» Отчёт о эколого-гидрогеологических изысканиях по объекту «Строительство совмещённой дороги Адлер-нижняя станция горнолыжного курорта «Роза Хутор»)

Таблица 1. Сезонные и годовые расходы воды р.Мзымта (у п.Красная Поляна, п.Кепш и Казачий Брод) и р.Сочи (у с.Пластунка и у г.Сочи) осредненные за параллельные периоды наблюдений (м³/с)

Река, гидроствор	Годы параллельных наблюдений	Ср.расход за гидрологический год			Ср.расход воды за холодный. период (ноябрь-март)			Ср.расход воды за теплый период (апрель-октябрь)			Расс. от устья, км
		сред	макс	минимум	сред	макс	минимум	сред	макс	мини	
Р. Мзымта-пос. Красная Поляна	1975–2002 (29 лет)	34,3	44,4	24,0	16,9	23,6	10,8	46,7	63,5	29,6	41,0
Р. Мзымта – Казачий Брод	1975–2002 (29 лет)	55,2	73,0	37,0	43,5	66,6	24,6	63,1	83,5	38,0	14,0
Р. Мзымта – Красная Поляна	1946–1967 (24 года)	32,2	42,4	24,2	19,0	28,1	10,0	41,6	55,0	29,6	41,0
Р. Мзымта – пос.Кепш	1946–1967 (24 года)	42,4	54,0	34,1	34,4	51,5	20,4	48,1	64,8	29,1	30,0
Р. Сочи – с. Пластунка	1944–1991 (50 лет)	16,1	23,0	9,3	18,9	28,0	10,8	14,1	25,6	6,0	15,0
Р. Сочи – г. Сочи	1944–1991 (50 лет)	16,1	22,0	9,4	19,7	29,9	11,5	13,6	22,0	5,2	1,0
Р. Сочи – с. Пластунка	1944–2005 (86 лет)	15,9	23,0	9,1	18,4	28,2	10,8	13,8	25,6	6,0	15,0
Р. Сочи – г. Сочи	1944–2005 (86 лет)	16,4	42,7	4,2	20,1	51,6	4,8	13,8	36,3	3,8	1,0
Р. Сочи – с. Пластунка	1992–2005 (15 лет)	14,4	20,0	9,1	16,1	20,1	11,5	13,1	22,1	7,3	15,0
Р. Сочи – г. Сочи	1992–2005 (15 лет)	17,6	26,3	10,3	21,6	37,9	13,5	14,8	21,6	8,0	1,0

При этом приняты следующие периоды наблюдений:

1. Река Мзымта – гидростворы у пос.Красная Поляна и у пос.Казачий Брод – 1975–2002 гидрологические годы – 29 лет.

2. Река Мзымта – гидростворы у пос.Красная Поляна и у пос.Кепш – 1946–1967 гг. – 24 года.

3. Река Сочи – гидростворы у с.Пластунка и у г.Сочи имеют параллельные наблюдения за период 1944–2005 гг – 61 год.

3. Обсуждение

Далее приводится анализ режима расходов воды р. Мзымта у пос. Красная Поляна и у пос. Кепш за период параллельных наблюдений с 1946 по 1967 гидрологические годы (Рисунок 5, 6, 7). Среднегодовые расходы воды за этот период в гидростворе Мзымта-Красная Поляна изменялись в пределах от 25 до 40 м³/с, а в гидростворе Мзымта – пос.Кепш – от 35 до 55 м³/с, т.е. прирост площади водосбора на 288 км2 дает прирост стока на 10-15 м³/с.

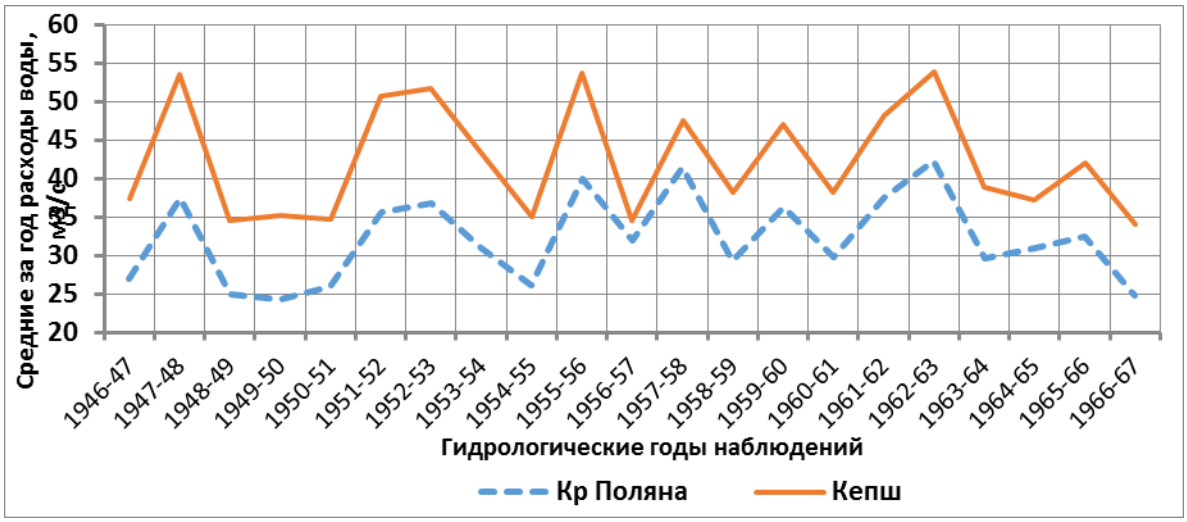

Рис. 5. Хронологический график среднегодовых расходов воды р. Мзымта у пос. Красная Поляна и у пос. Кепш

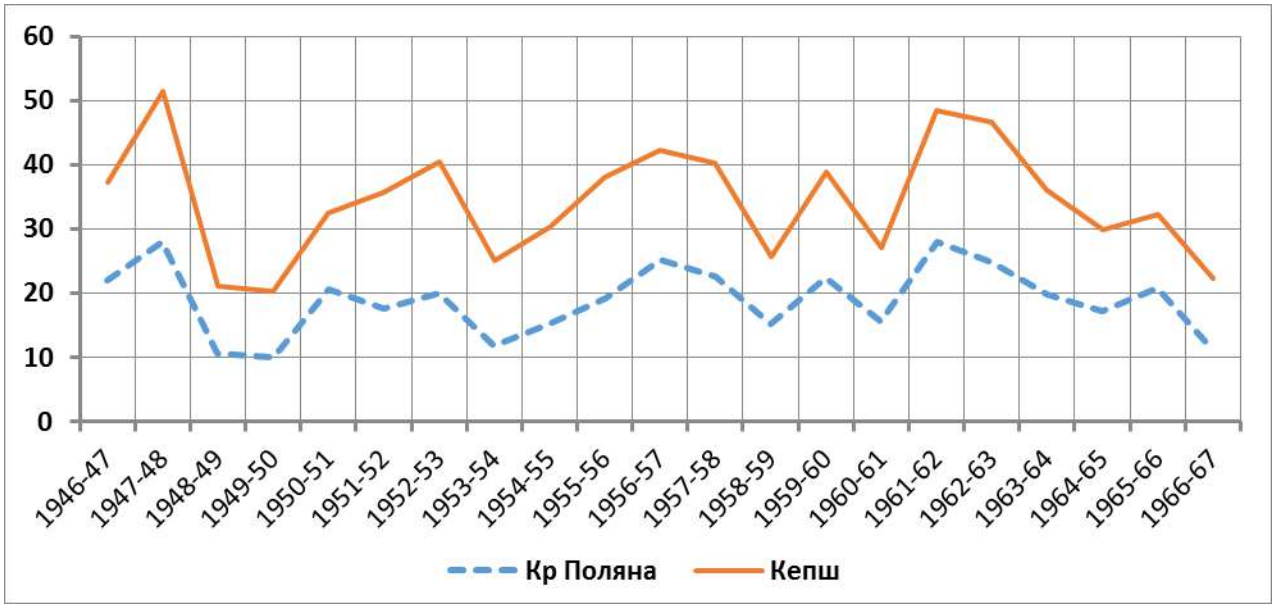

Рис. 6. Хронологический график средних за холодный период расходов воды р. Мзымта у пос. Красная Поляна и у пос. Кепш

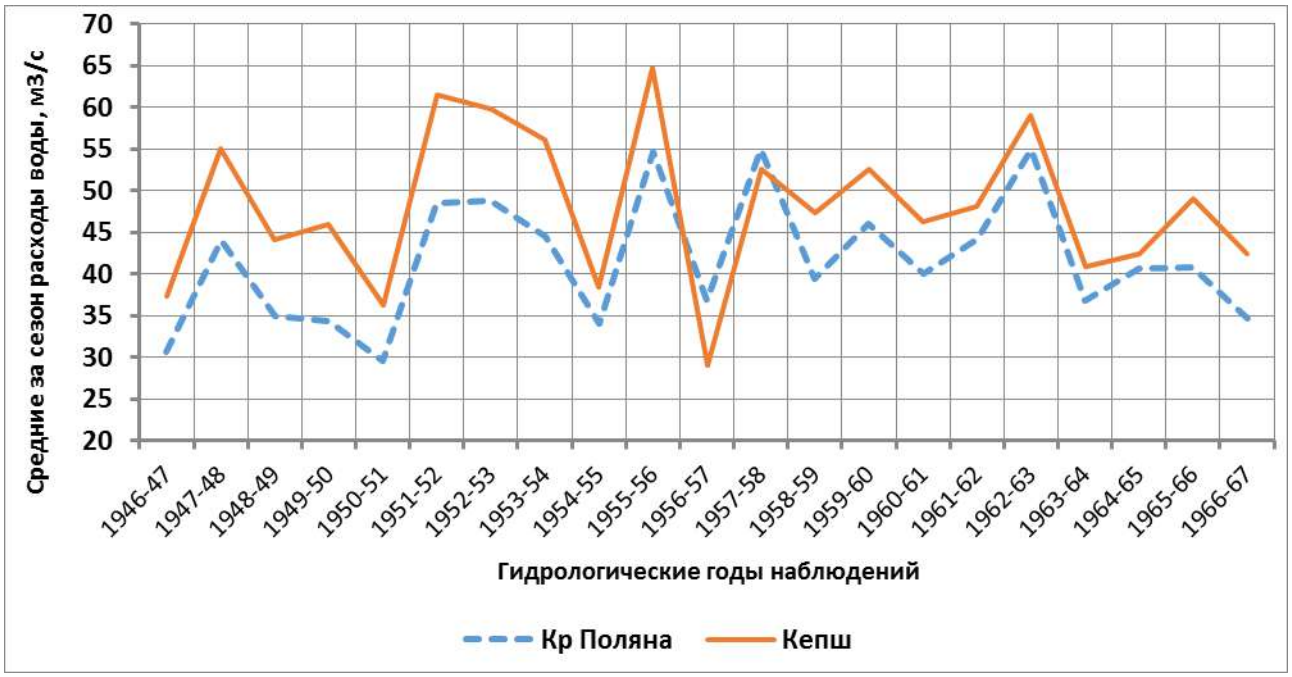

Рис. 7. Хронологический график средних за теплый период расходов воды р. Мзымта у Красной Поляны и у пос. Кепш

Среднегодовой расход воды у Красной Поляны равен 41,6 м³/с, а у пос. Кепш 48,1 м³/с, следовательно разница составляет 6,5 м³/с. Расчет прироста стока с этой площади дает величину 420 мм слоя.

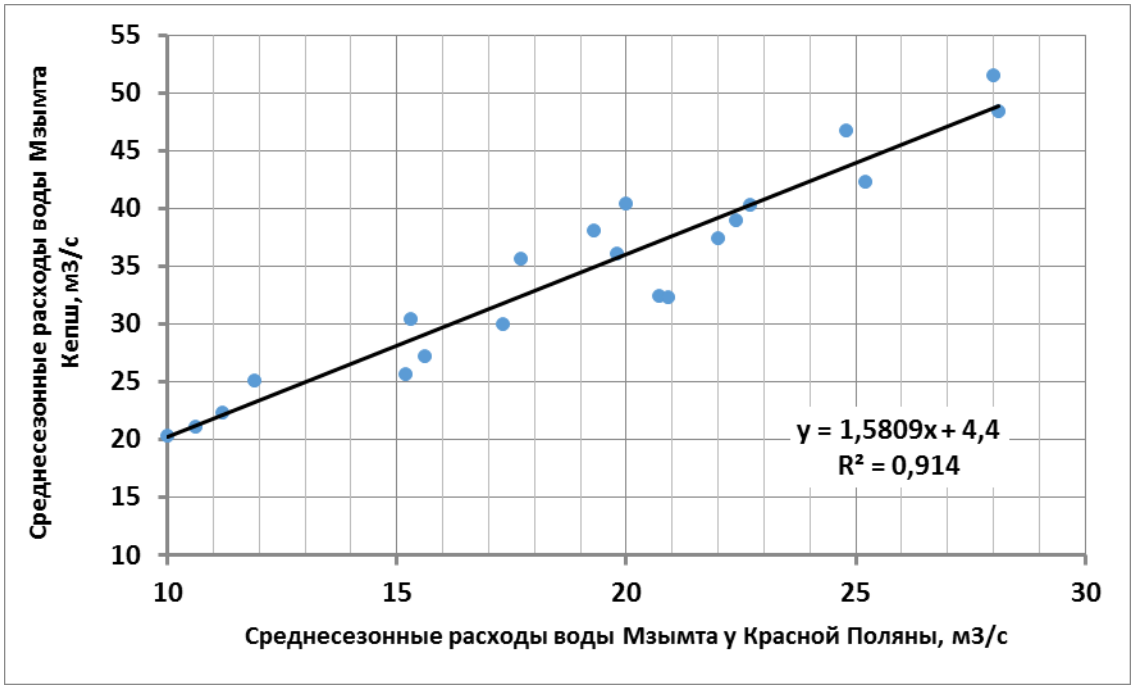

Рис. 8. Зависимость между среднесезонными расходами воды р. Мзымта у пос. Красная Поляна и у пос. Кепш за холодный период

На Рисунках 8 и 9 показаны зависимости средних за сезоны расходов воды на гидростворах красная Поляна и Кепш, которые имеют высокую степень корреляции (R^2 = 0.72-0.91).

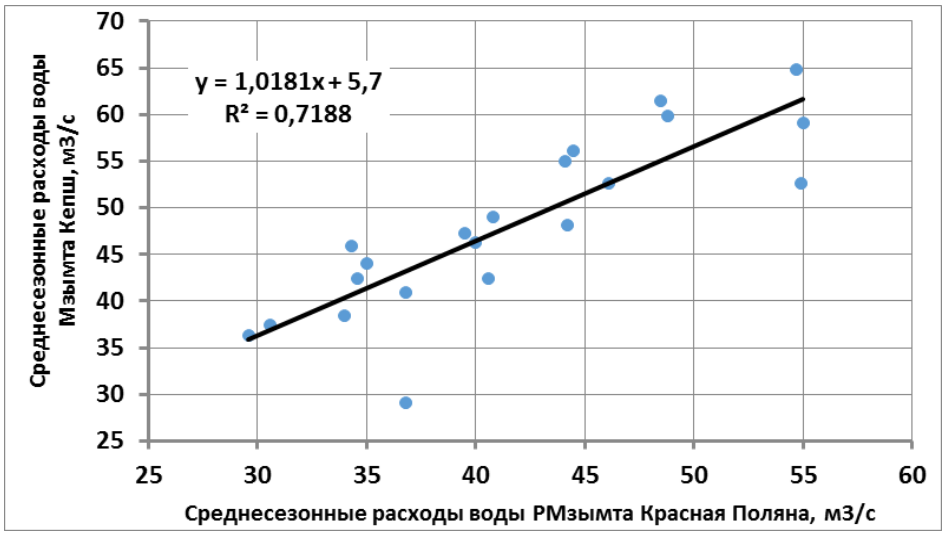

Рис. 9. Зависимость между средне-сезонными расходами воды р. Мзымта у пос. Красная Поляна и пос. Кепш за теплый сезон

Следующий период параллельных наблюдений за стоком (1975–2002 гидр. годы) связан с переносом гидроствора р. Мзымта у пос. Кепш на пост в 14 км от устья Мзымты – пос. Казачий Брод. На Рисунках 10, 11 и 12 показана динамика среднегодовых и сезонных расходов воды на гидростворах р. Мзымта – пос. Красная Поляна и Мзымта – Казачий Брод.

Среднегодовой расход воды за период 1975-2002 гг. у пос.Красная Поляна равен 34,3 м³/с, а у пос Казачий Брод – 55,2 м³/с. При приросте площади водосбора 839 км² – 510 км² = 329 км² прирост расхода воды в среднем составил 20,9 м³/с.

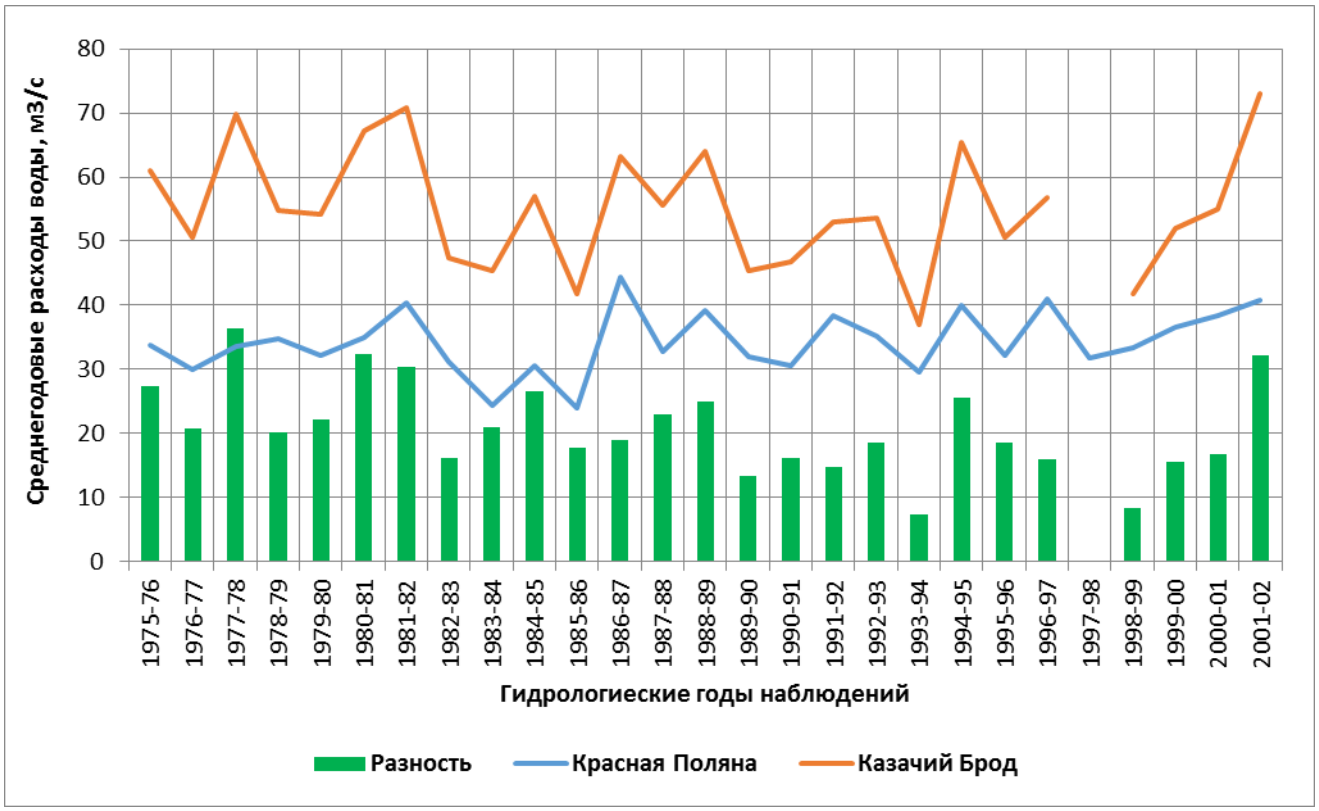

Рис. 10. Хронологический график среднегодовых расходов воды р. Мзымта у Красной Поляны и Казачий Брод

Рис. 11. Хронологический график средних за сезон расходов воды р.Мзымта у Красной Поляны и у пос. Казачий Брод за холодный период

Как следует из приведенных графиков, средние за холодный период расходы воды за период 1975–2002 гг. у пос.Красная Поляна составили 16,9 м³/с, а у пос.Казачий Брод – 43,5 м³/с. Прирост среднего за холодный период расхода воды равен 26,6 м³/с, или увеличение стока в 1,6 раза. При этом на гидростворе Красная Поляна в холодный период наблюдается более выровненный ход расходов воды, что объясняется процессами снегонакопления в высокогорной части бассейна реки Мзымта.

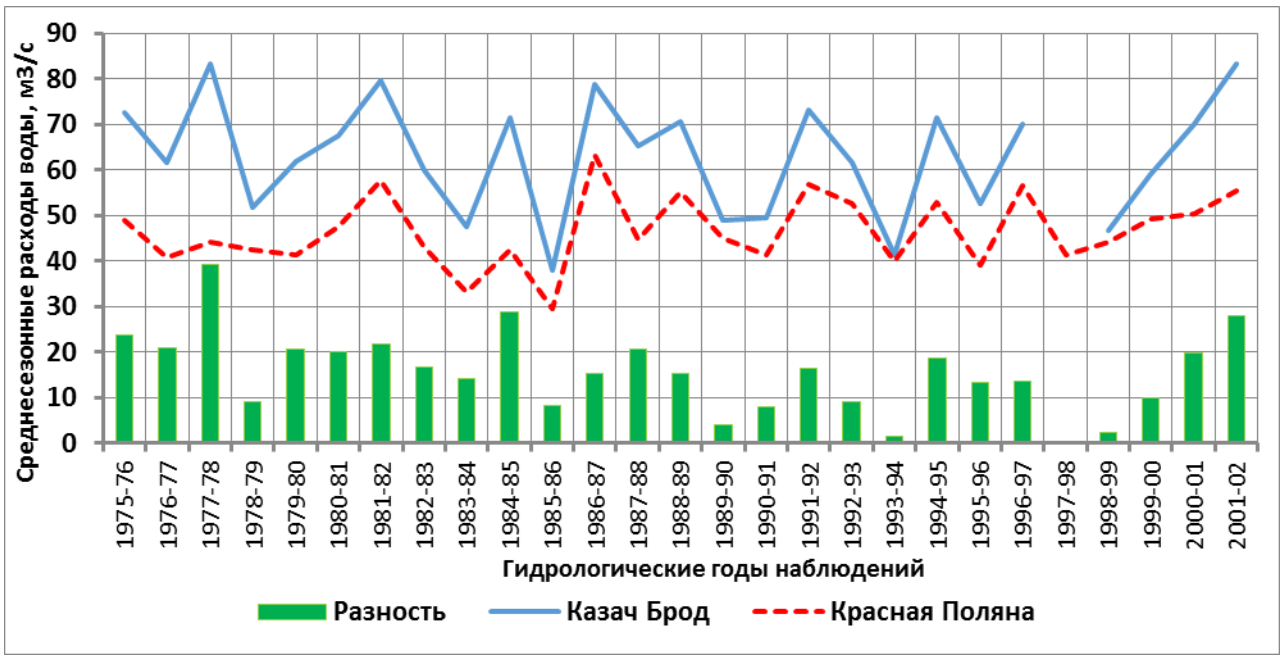

Рис. 12. График связи сезонных расходов воды Мзымта у пос.Красная Поляна и у пос.Казачий Брод за теплый период

Средние за теплый период расходы воды за период 1975-2002 гг. у пос. Красная Поляна составили 46,7 м³/с, а у пос. Казачий Брод – 63,1 м³/с. Прирост среднего за теплый

период расхода воды 16,4 м³/с, т.е. слой стока с прироста площади 319 км² равен 16,4*56,98 = 934,5 мм слоя.

При этом связь стока р. Мзымта у пос. Красная Поляна и у пос.Казачий Брод за холодный период практически отсутствует (y = 1,4394x + 19,2 при R^2 = 0,21), а для среднегодовых расходов воды R^2=0.47 (Рисунок 13). Это является результатом распределения территории водосбора по высотным зонам. Так, при средней высоте бассейна Мзымты 1400 м над ур. моря к высокогорной части (выше 1800 м над ур. моря) относятся 32 % площади, к среднегорной – от 600 до 1800 м НУМ – 56 %, к низкогорной части – от 200 до 600 м НУМ относятся 10 % территории, и к полого-холмистому рельефу тяготеют только 2 % площади водосбора.

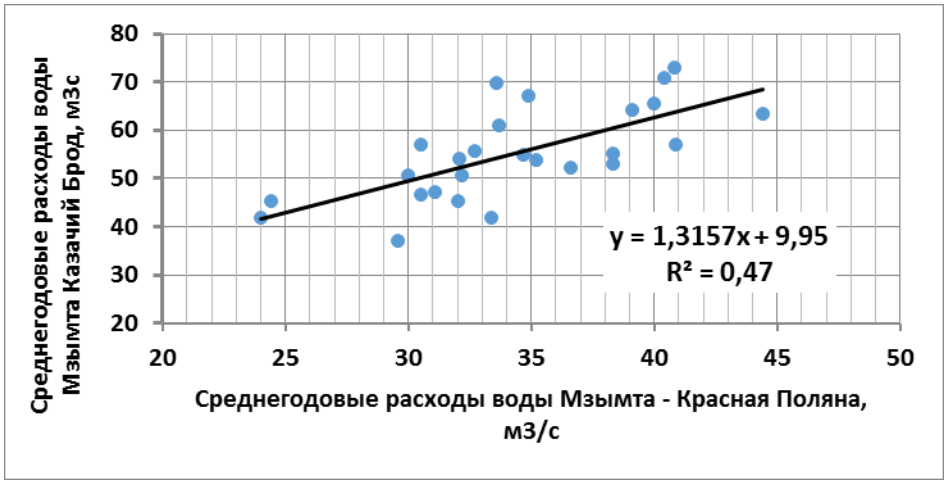

Рис. 13. График связи среднегодовых расходов воды река Мзымта у пос. Красная Поляна и Казачий Брод

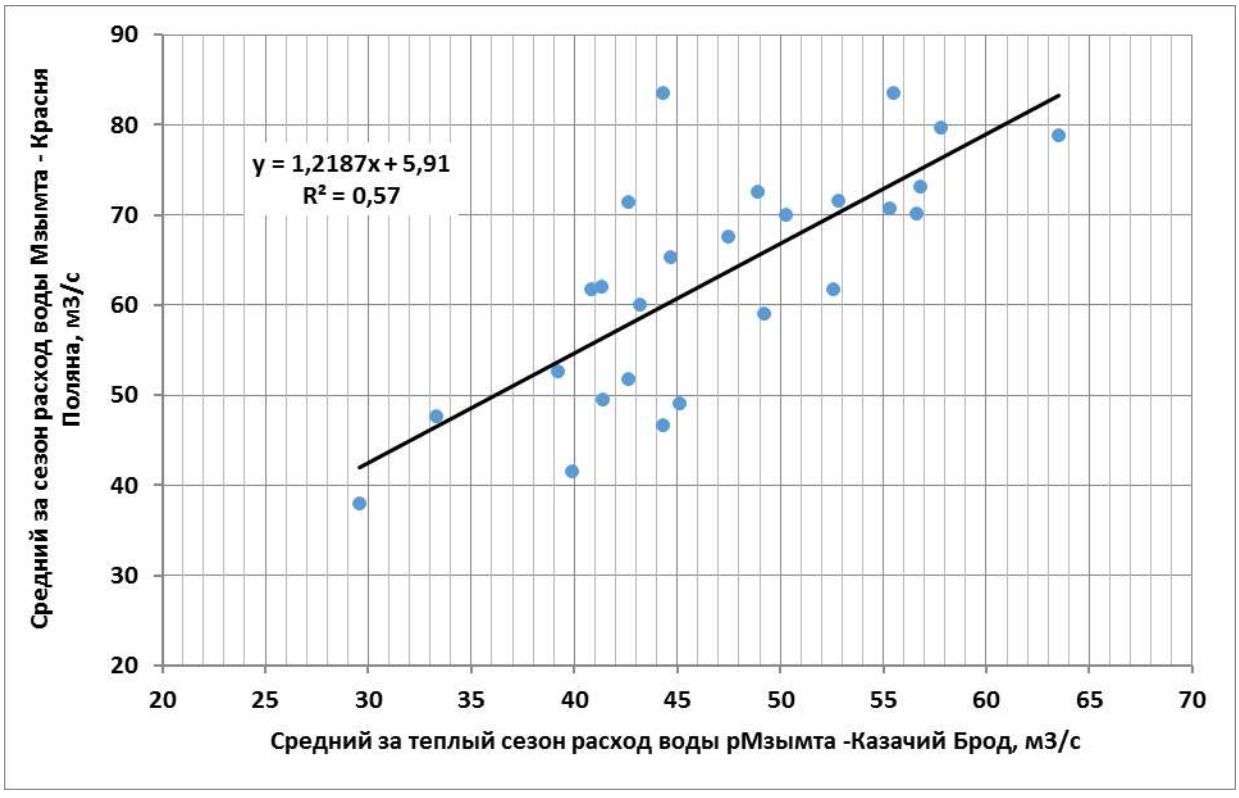

Рис. 14. График связи сезонных расходов воды Мзымта у пос.Красная Поляна и у пос.Казачий Брод за теплый период

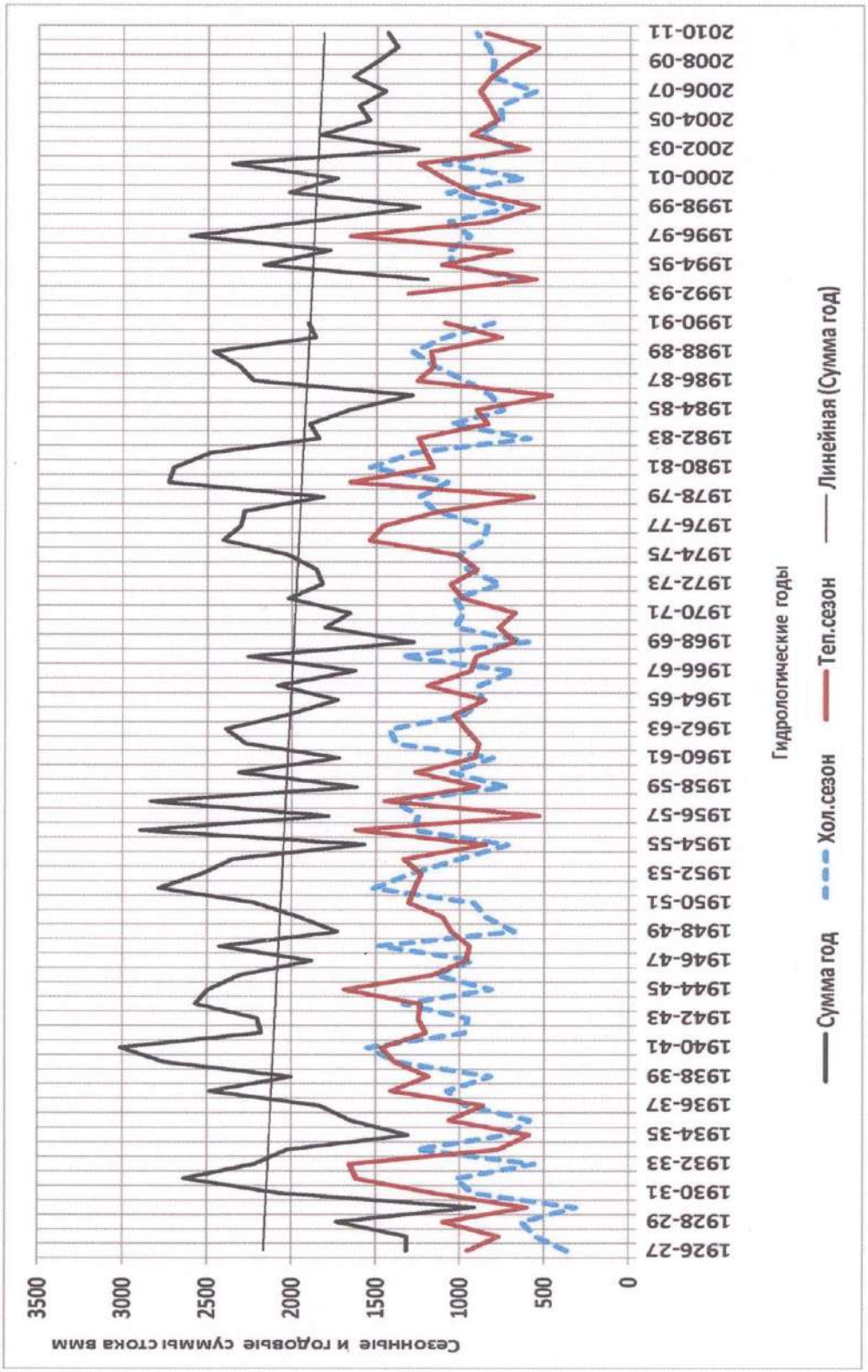

Рис. 15. Средние за сезоны и гидрологические годы расходы воды реки Сочи у с. Пластунка за период наблюдений 1926-2011 гидр. годы

Несколько выше уровень связи расходов воды этих двух гидростворов наблюдаются в теплый период, что связано с формированием стока реки в разных высотных зонах бассейна (Рисунок 14).

Анализ материалов параллельных наблюдений на реке Сочи дает следующие результаты. Наблюдения за стоком реки Сочи у с. Пластунка относятся к наиболее продолжительному сроку из всех проводимых на Черноморском Побережье Кавказа – с 1926 по 2011 гидрологические годы (86 лет). (Рисунок 15).

Эти наблюдения характеризуют режим формирования речного стока на основной высокогорной и среднегорной части бассейна реки (238 км² из общей площади бассейна 296 км². При средней высоте бассейна 850 м над ур.моря к высокогорной части (выше 1800 м над ур.моря) относятся 2 % площади, к среднегорной – от 600 до 1800 м НУМ – 70 %, к низкогорной части – от 200 до 600 м НУМ относятся 20 % территории, и к полого-холмистому рельефу тяготеют только 2 % площади водосбора.

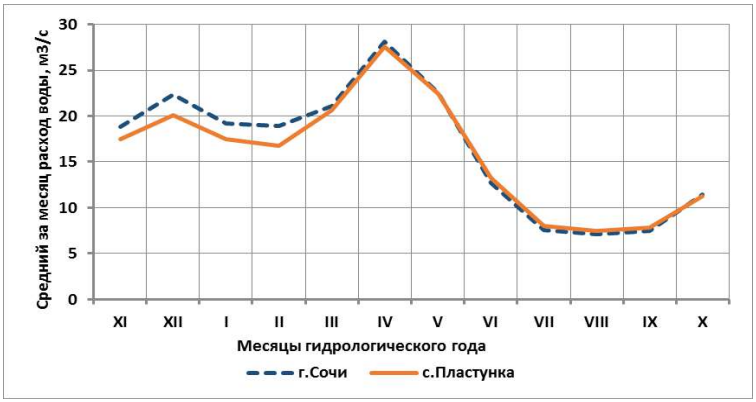

Рис. 16. Нормы месячного стока реки Сочи у г.Сочи и у с.Пластунка, м³/с

Вследствие особенностей высотного расположения бассейна реки Сочи внутригодовое распределение стока реки характеризуется превалированием стока холодного периода над стоком теплого сезона (в среднем в 2 раза) (Рисунок 16).

Параллельные наблюдения за стоком реки Сочи (гидроствор р. Сочи у г. Сочи – в 1 км от устья) имеют более короткий период – с 1944 по 2005 гидр. годы (Рисунок 17). Из анализа этого графика следует, что в период 1944–1991 гг. среднегодовые расходы воды обоих постов практически совпадают, т.е. прирост площади водосбора на участке с. Пластунка – г. Сочи на 58 км² в среднем равен 0.

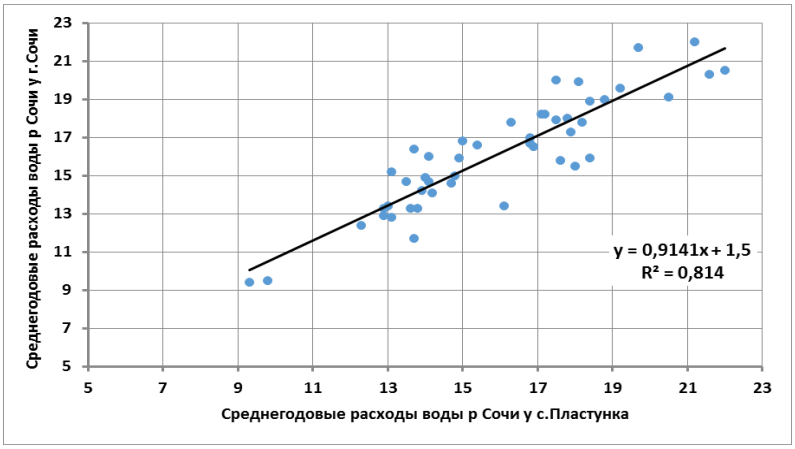

Рис. 17. График связи среднегодовых расходов воды р Сочи у с. Пластунка и у г. Сочи за период 1944–1991 гг.

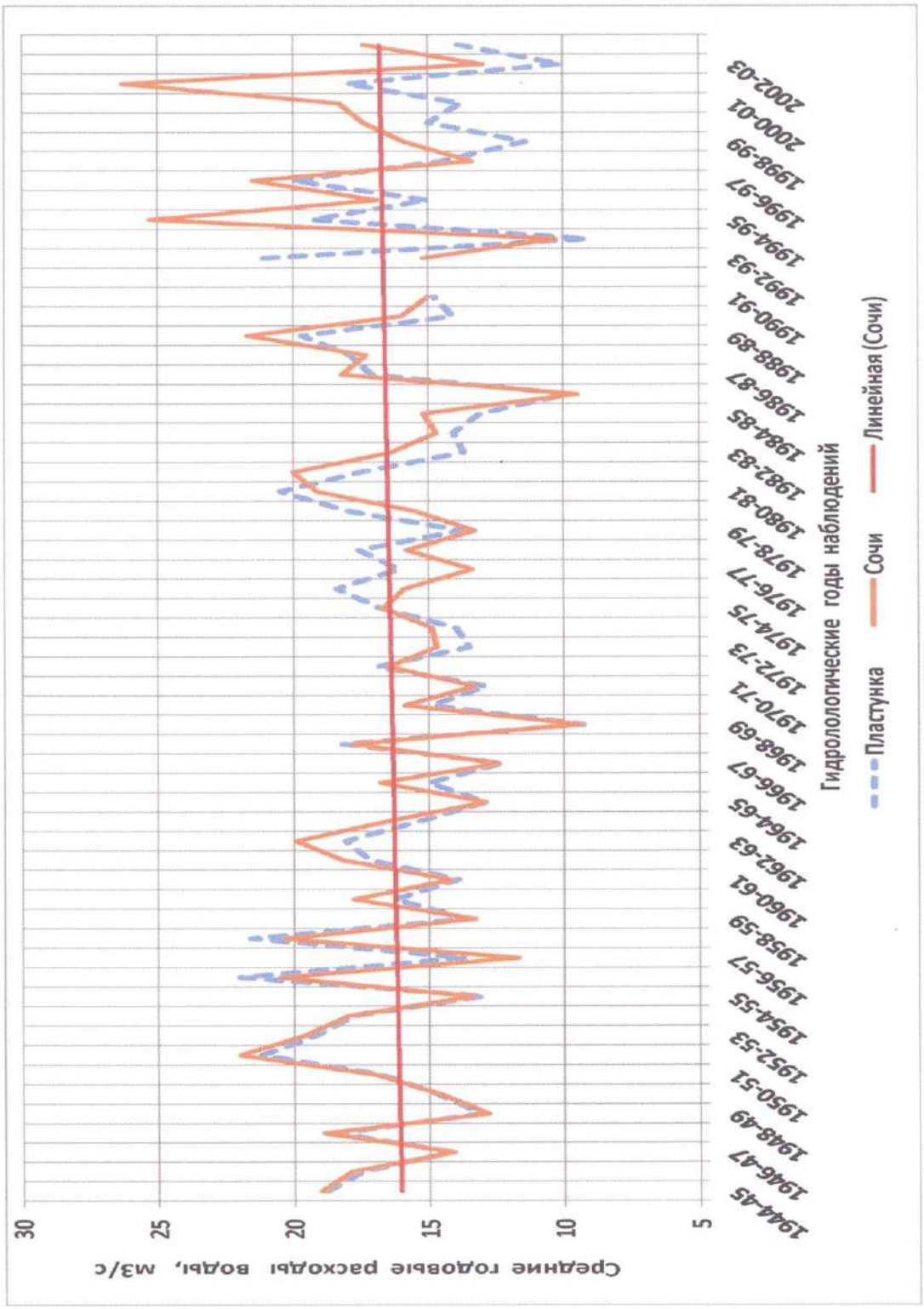

Рис. 18. Хронологический график среднегодовых расходов воды реки Сочи у с. Пластунка и у г. Сочи за период параллельных наблюдений (1944–2003 гидр. годы)

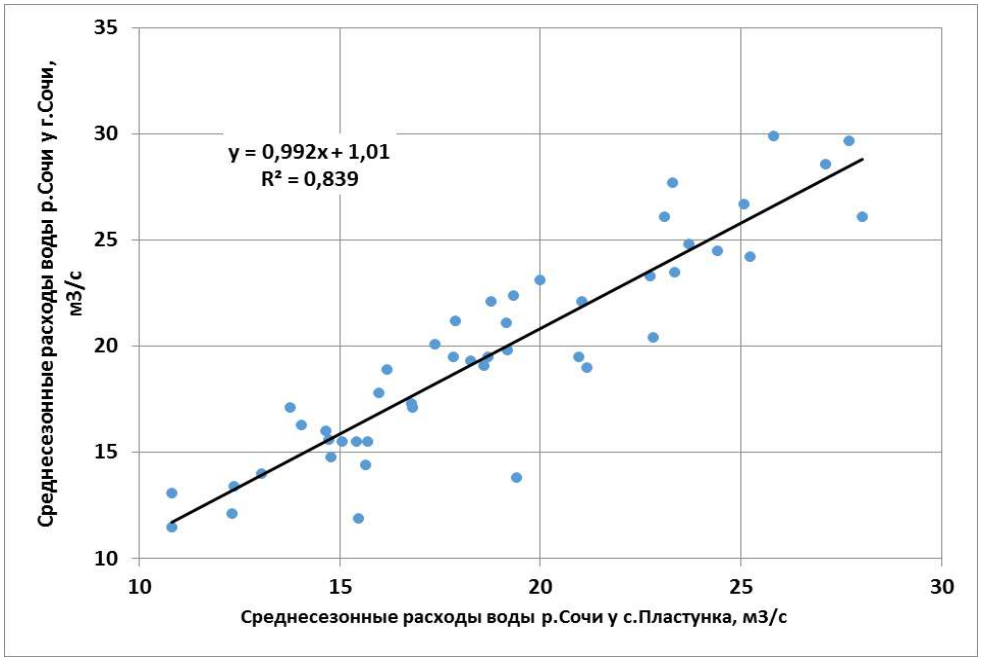

Рис. 19. График связи средних сезонных расходов воды р. Сочи у с. Пластунка и у г. Сочи за холодный период 1944–1991 гг.

Графики связи среднегодовых и среднесезонных расходов воды за этот период имеют высокую степень корреляции (R^2=0.81-0.86) – Рисунки 17, 19 и 23). На Рисунках 18 и 21 приведены хронологические графики динамики среднезезонных расходов воды на гидростворах р. Сочи у с. Пластунка и г. Сочи у г. Сочи.

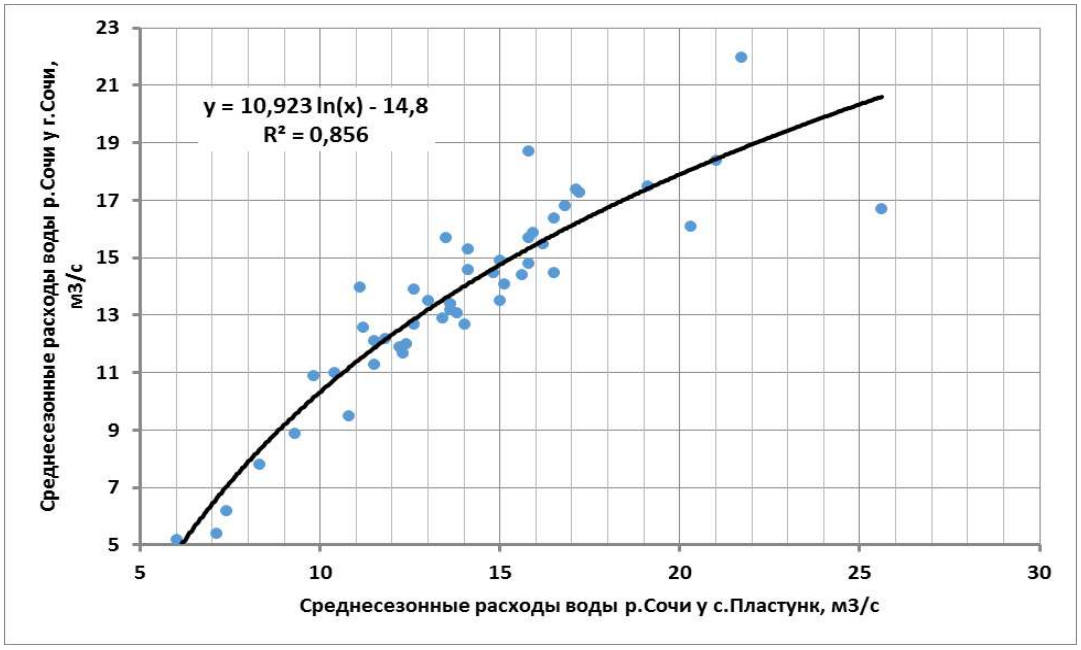

Рис. 20. График связи среднесезонных расходов воды р.Сочи у с.Пластунка и у г. Сочи за период 1944–1991 гг. (теплый сезон)

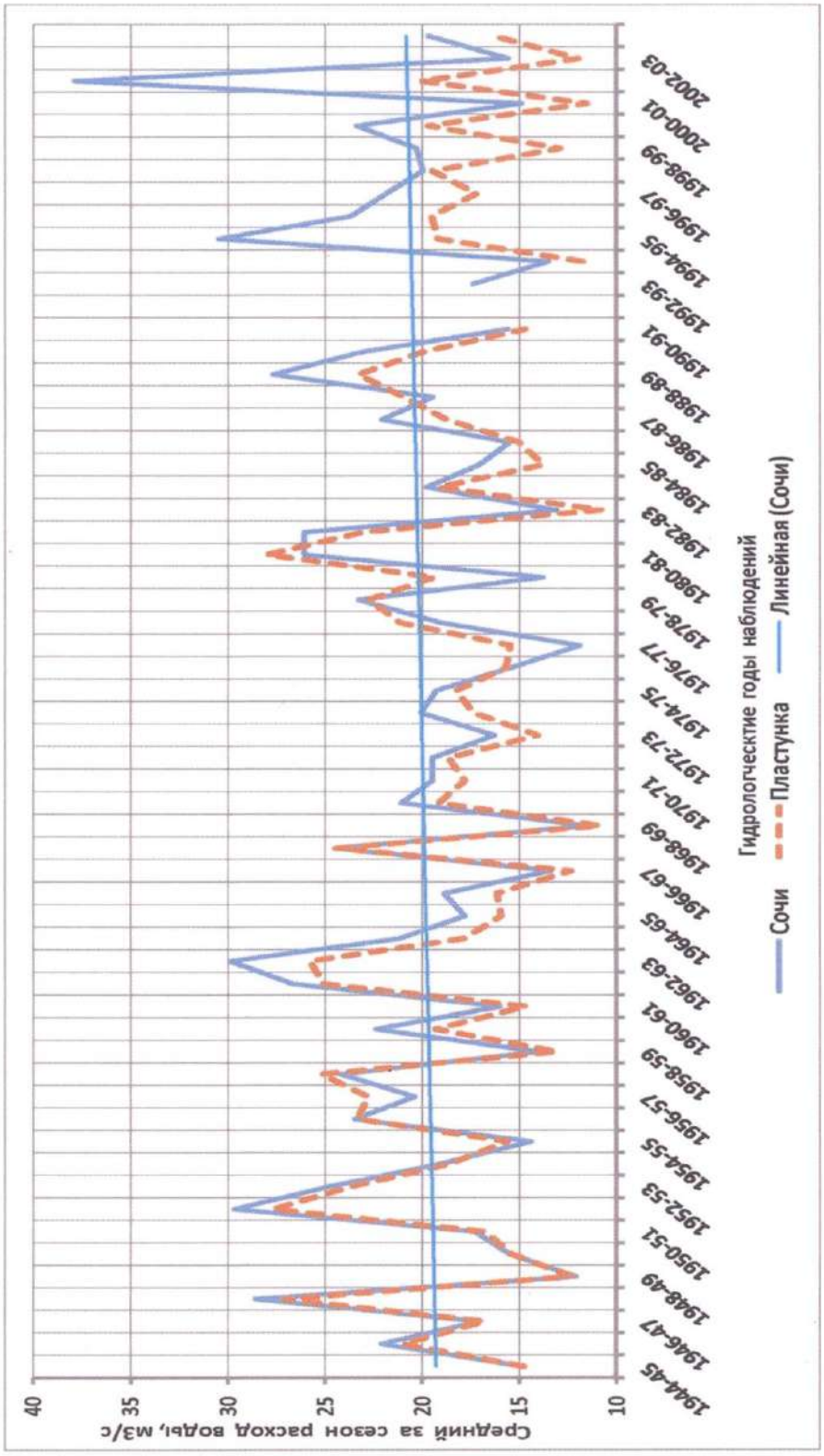

Рис. 21. Хронологический график среднесезонных расходов воды реки Сочи у с. Пластунка и у г.Сочи за период параллельных наблюдений 1944–2003 гидр. годы (за холодный период)

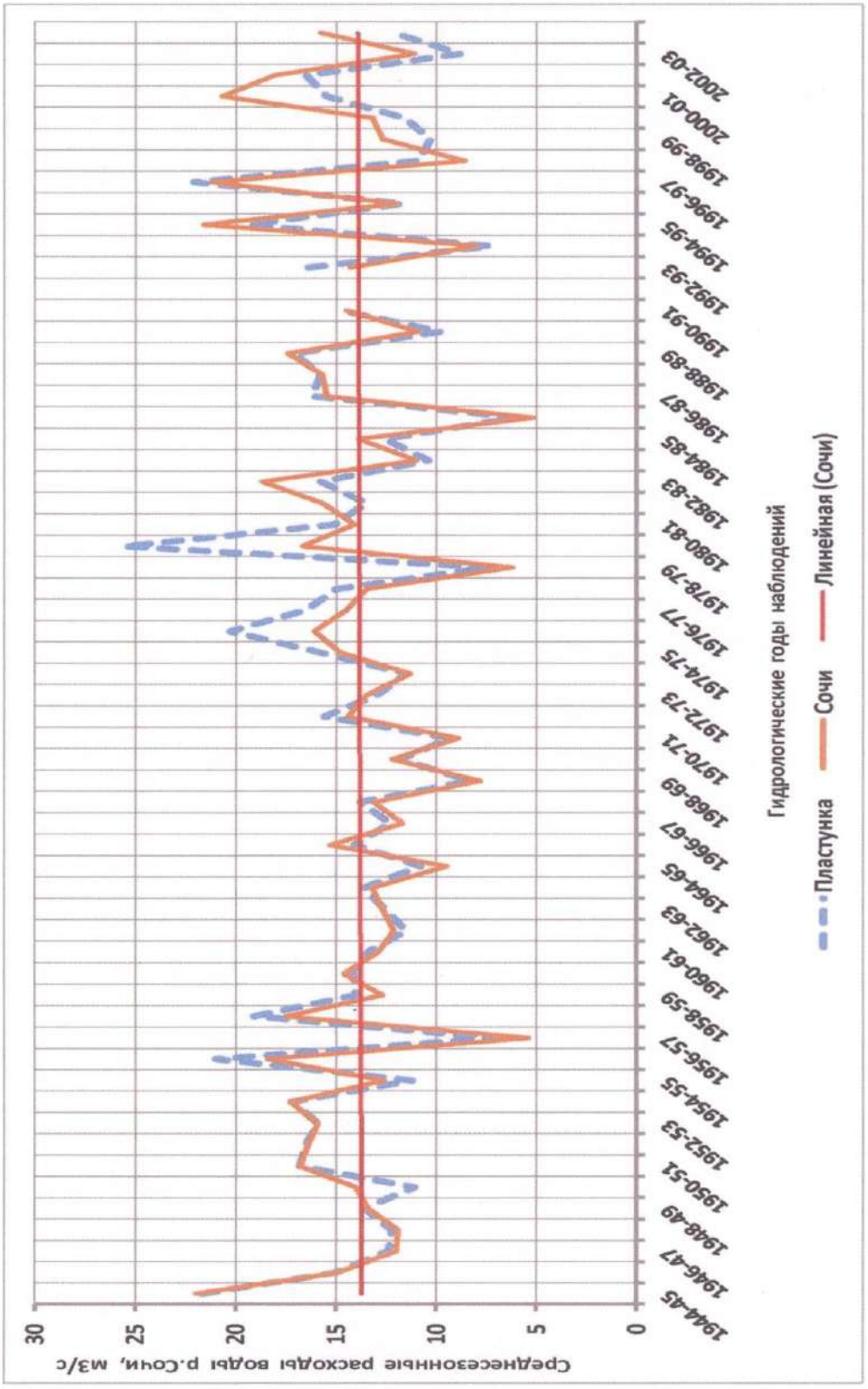

Рис. 22. Хронологический график среднесезонных расходов воды реки Сочи у с. Пластунка и у г. Сочи за период параллельных наблюдений 1944–2003 гидр. годы (за теплый период)

За период наблюдений последних 15 лет наблюдается резкое повышение среднесезонных расходов воды на посту р. Сочи у г. Сочи и уменьшение точности взаимосвязей (Рисунок 23).

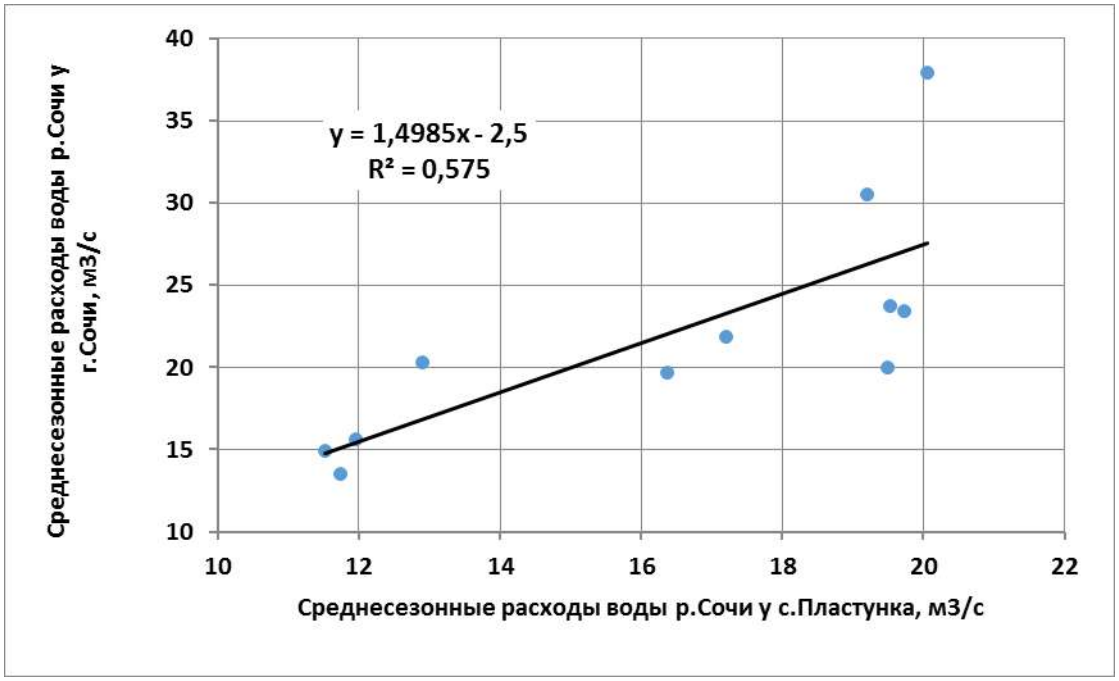

Рис. 23. График связи средних сезонных расходов воды р. Сочи у с. Пластунка и г. Сочи холодный период 1991–2004 гг.

Возможно этот факт объяснить изменением поверхности бассейна в виде интенсивной городской застройки этой части водосбора, повлекшее увеличение коэффициента стока с этой части водосбора.

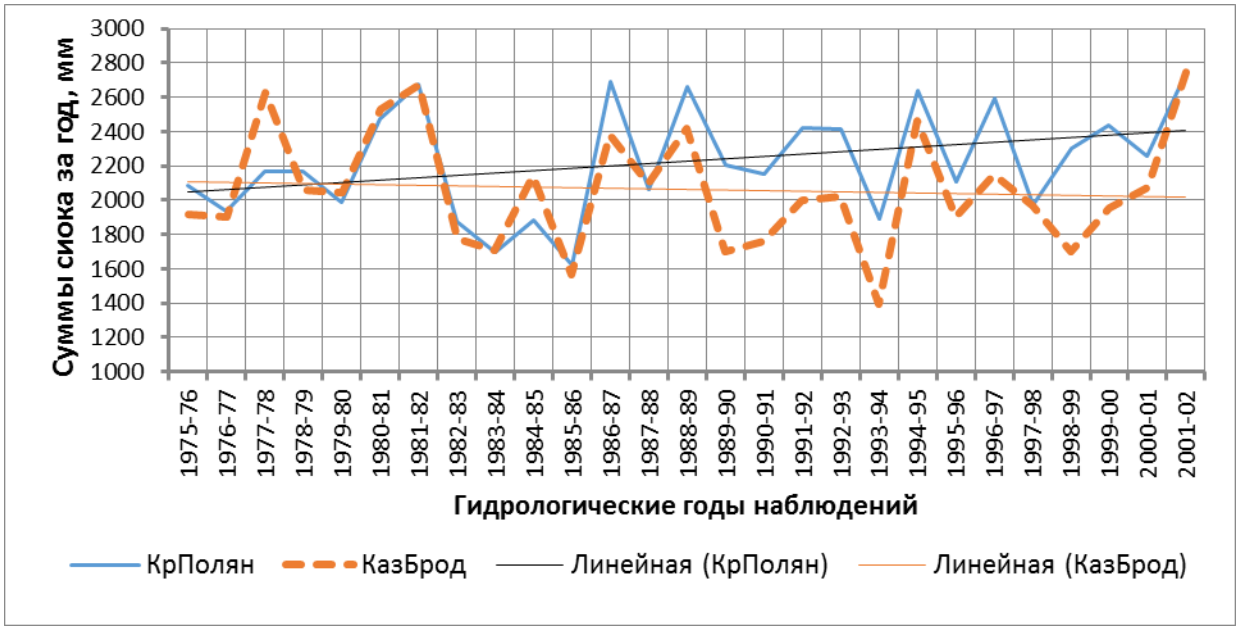

Рис. 24. Хронологический график динамики годового стока р. Мзымта у р. п. Красная Поляна и у пос. Казачий Брод

Анализ режима стока рек Мзымта и Сочи. Помимо приведенного выше анализа режима расходов воды этих рек выполнен анализ режима речного стока в виде рассчитанных слоев стока, осредненных по площади водосбора в мм.

В Таблице 2 даны аналогичные приведенным выше материалам по расходам воды (Таблица 1) (за указанные периоды) по суммарному стоку – суммы стока в мм слоя за холодный и теплый сезоны, и в целом суммы за гидрологический год.

Таблица 2. Сезонные и годовые суммы стока р. Мзымта (у пос. Красная Поляна, пос. Кепш и Казачий Брод) и р. Сочи (у с. Пластунка и у г. Сочи) осредненные за периоды параллельных наблюдений (мм слоя)

Река, гидроствор	Годы параллельных наблюдений	Сток за гидрологический год			Сток за холодный. период (ноябрь-март)			Сток за теплый период (апрель-октябрь)			Площ. водосбора
		сред	макс	миним	сред	макс	миним	сред	макс	мини	
Р. Мзымта-пос. Красная Поляна	1975–2002 (29 лет)	2228	2740	1626	528	752	312	1693	2300	1069	510
Р. Мзымта – Казачий Брод	1975–2002 (29 лет)	2066	2747	1394	678	1041	324	1388	1844	835	829
Р. Мзымта – Красная Поляна	1946–1967 (24 года)	1991	2361	1499	485	724	258	1506	1994	1073	510
Р. Мзымта – пос.Кепш	1946–1967 (24 года)	1675	2134	1351	564	839	336	1111	1499	668	798
Р. Сочи – с. Пластунка	1944–1991 (50 лет)	2096	2896	1279	1029	1538	592	1067	1684	464	238
Р. Сочи – г. Сочи	1944–1991 (50 лет)	1715	2326	1003	868	1325	514	847	1371	325	296
Р. Сочи – с. Пластунка	1944–2005 (61 лет)	1993	960	1041	960	1548	313	1041	1684	464	238
Р. Сочи – г. Сочи	1944–2005 (61 лет)	1747	2808	1002	863	1681	286	870	1371	325	296
Р. Сочи – с. Пластунка	1992–2005 (15 лет)	1801	2603	1206	886	1106	632	961	1655	547	238
Р. Сочи – г. Сочи	1992–2005 (15 лет)	1833	2809	1098	905	1681	461	956	1371	500	296

На Рисунке 24 приведен хронологический график динамики годовых сумм стока р. Мзымта у р. п. Красная Поляна и у пос. Казачий Брод Можно видеть, что годовой слой стока в верхнем створе (Красная Поляна) в основном больше, чем в нижележащем гидростворе. Средний годовой слой стока за период 1975-2002 годы у пос. Красная Поляна равен 2228 мм, а у пос. Казачий Брод – 2066 мм. Следовательно, разница составляет 162 мм при приросте площади водосбора 329 км².

На Рисунке 25 показан хронологический график сезонных сумм стока р. Мзымта у пос. Красная Поляна и Казачий Брод за холодный сезон, где величины стока у Казачьего Брода выше, чем у пос. Красная Поляна. Следовательно, уменьшение стока в нижнем створе (Казачий Брод) происходит за счет теплого периода (Рисунок 26). Разница в стоке р. Мзымта за теплый период в среднем составляет около 300 мм (в Красной Поляне сток 1680 мм выше, чем в Казачьем Броде – 1387 мм).

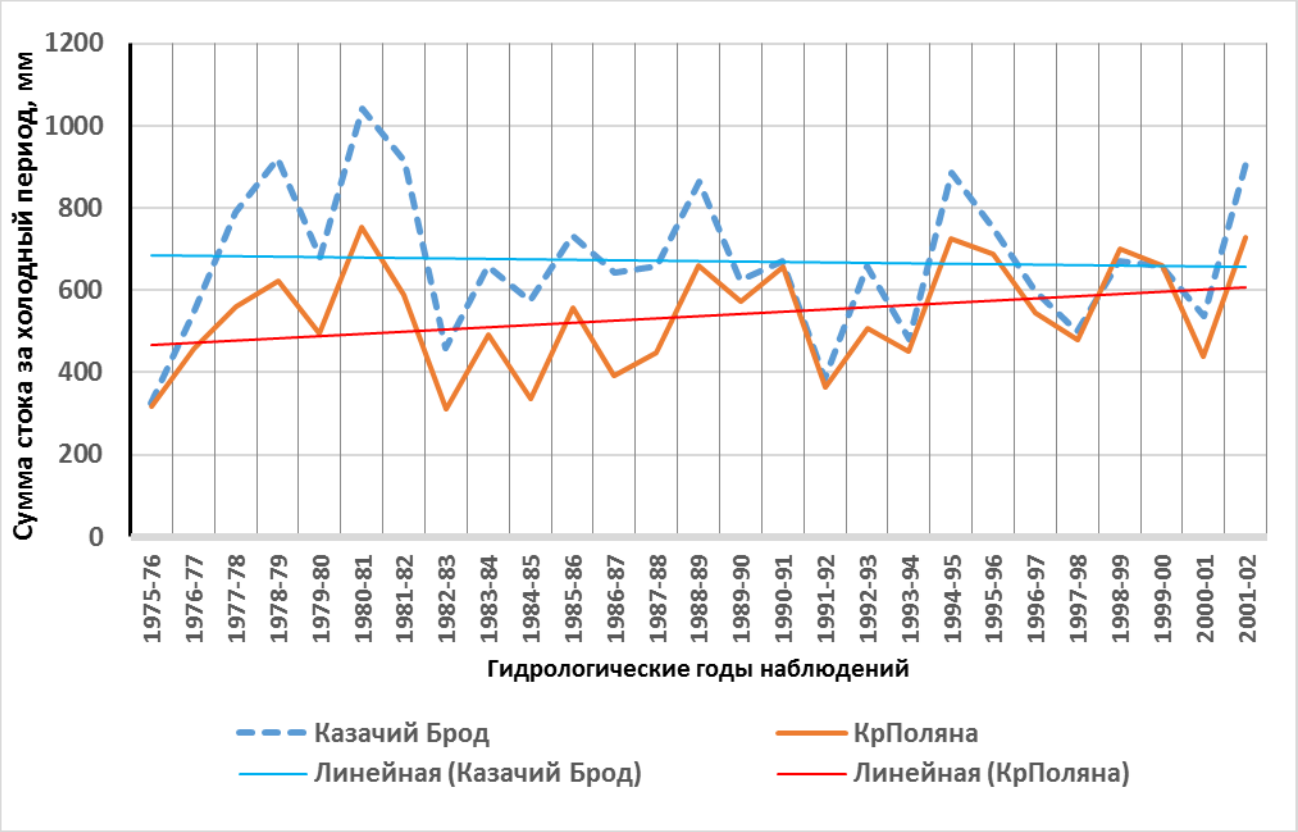

Рис. 25. Хронологический график сезонного стока реки Мзымта у пос. Красная Поляна и у пос. Казачий Брод за холодный период 1975-2002 гидр. годы

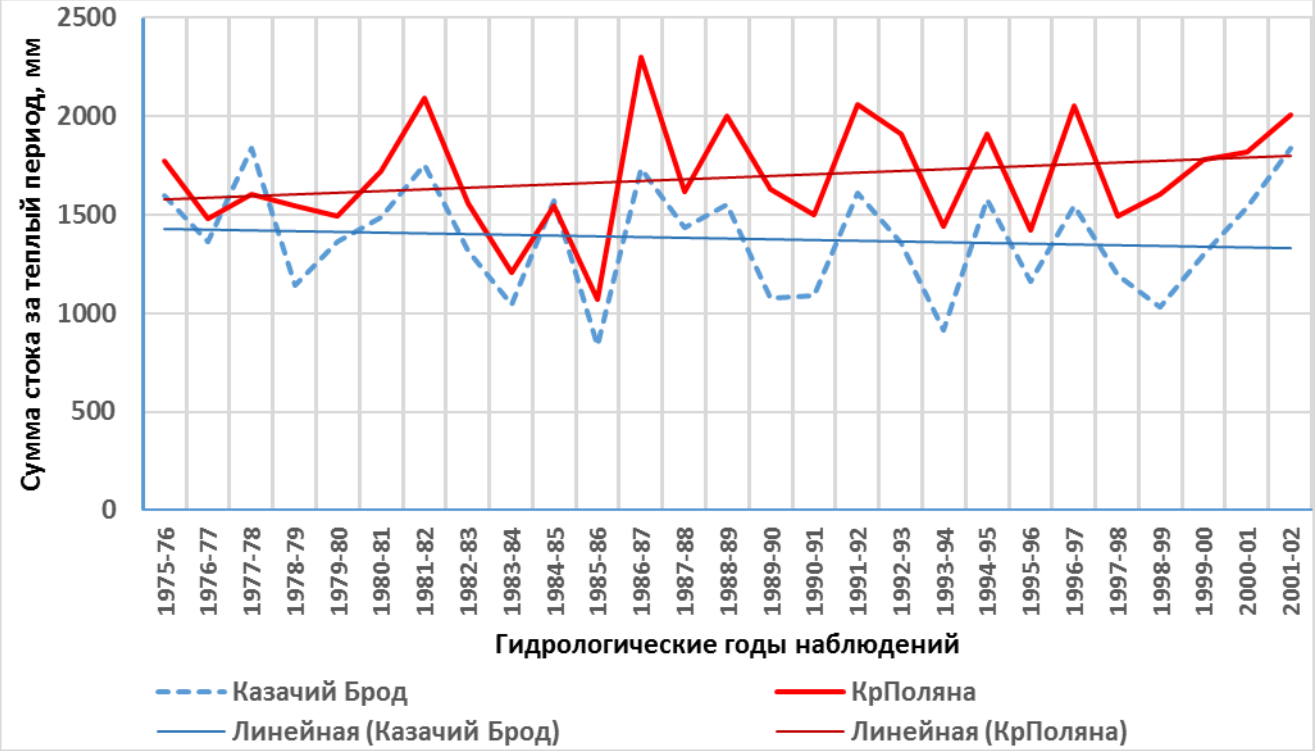

Рис. 26. Хронологический график сезонного стока р. Мзымта за теплый период у р. п. Красная Поляна и Казачий Брод (в мм слоя)

При этом взаимосвязи сумм стока за холодный и теплый сезоны этих двух гидростворов (пос. Красная Поляна и пос. Казачий Брод) характеризуется средней степенью тесноты (R^2 = 0.58-0.65) (Рисунок 27 и 28)

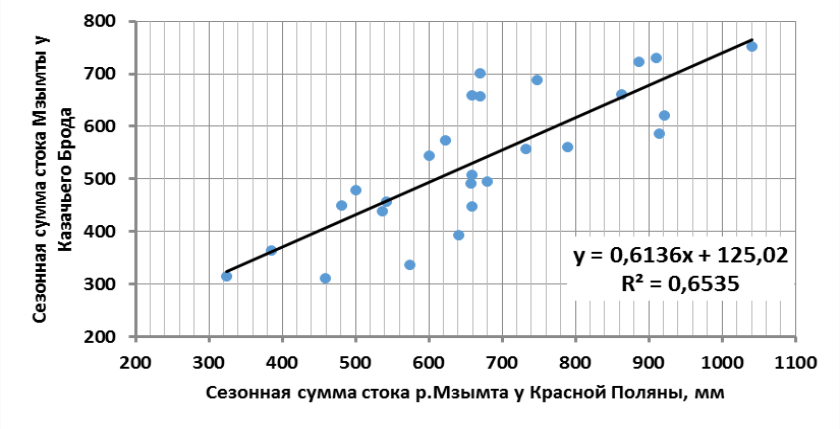

Рис. 27. Связь сумм стока за холодный период р. Мзымта у Красной Поляны и у Казачьего Брода

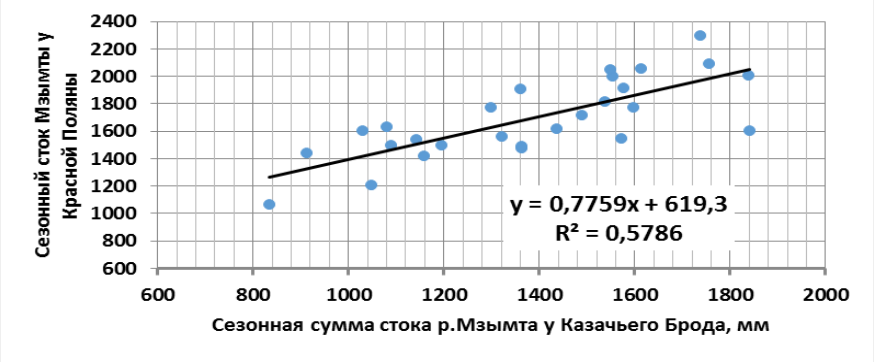

Рис. 28. Связь сезонного стока р. Мзымта у Казачьего Брода и у Красной Поляны за теплый период

Связь стока р. Мзымта у пос. Красная Поляна и у пос. Кепш можно характеризовать периодом параллельных наблюдений – с 1946 года по 1967 г (24 гидрологических года).

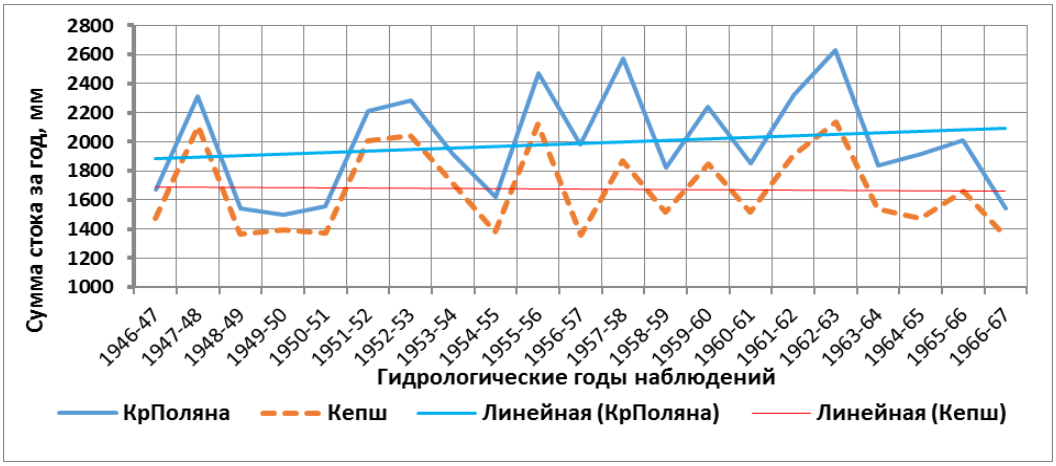

Рис. 29. Хронологический график годовых сумм стока р. Мзымта у пос. Красная Поляна и пос. Кепш за период наблюдений 1946–1967 гг.

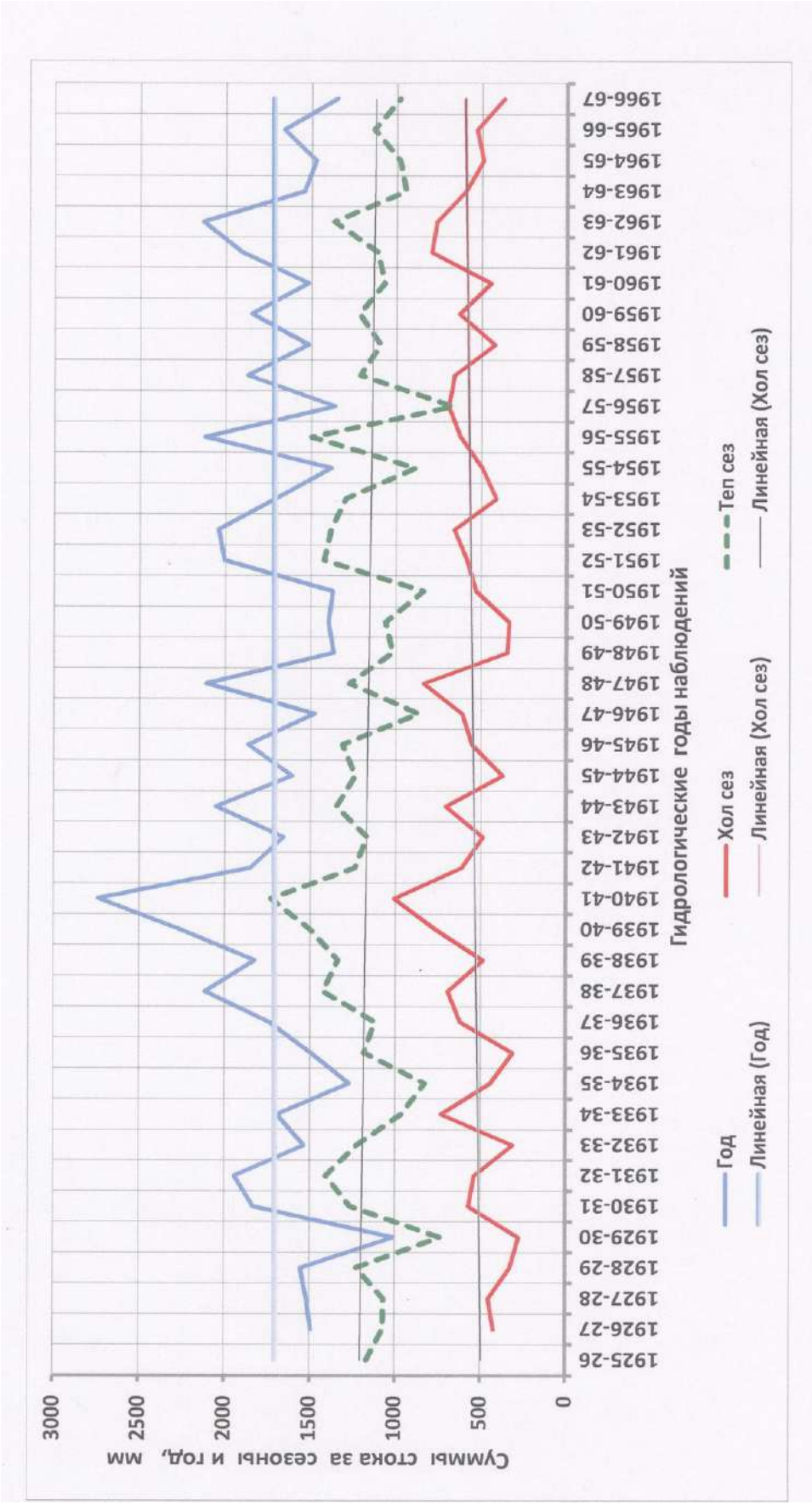

Рис. 30. Хронологический график стока реки Мзымта у пос. Кепш за весь период наблюдений 1926–1967 гг.

В среднем за гидрологический год у пос. Кепш сток меньше, чем у пос. Красная Поляна, на 1675–1991 = 316 мм (при увеличении площади водосбора на этом участке в 288 км²). При этом в холодный период сток на нижележащем посту в пос. Кепш больше на 484,9-563,6 = 78,7 мм (Рисунки 29, 31). За теплый период разница в сумме стока 1506,5 – 1111,3 = 395,2 мм – в пос. Кепш меньше (Рисунок 32).

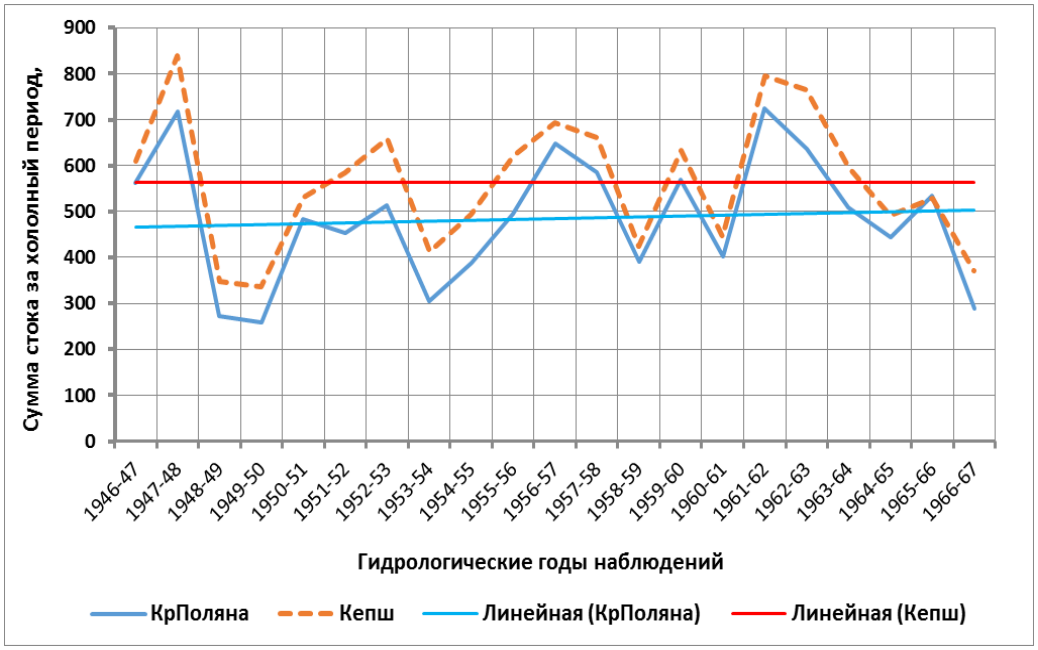

Рис. 31. Хронологический график сезонного стока за холодный период р. Мзымты у пос. Красная Поляна и пос. Кепш

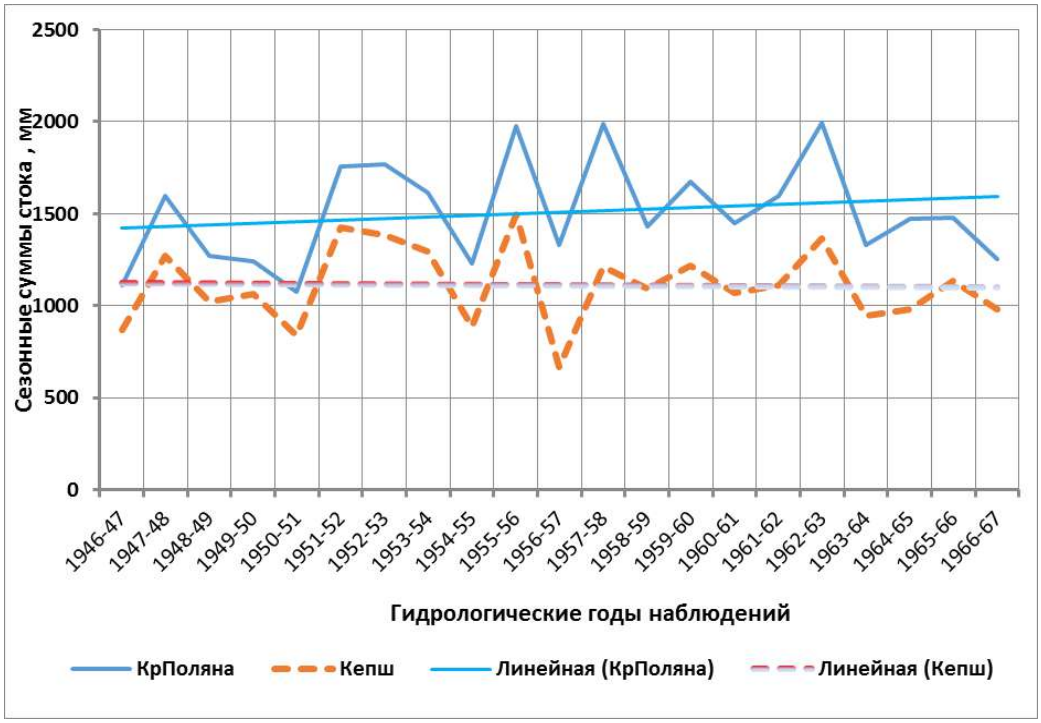

Рис. 32. Хронологический график сезонного стока за теплый период р. Мзымта у пос. Красная Поляна и пос. Кепш за период 1946–1967 гидр. годы

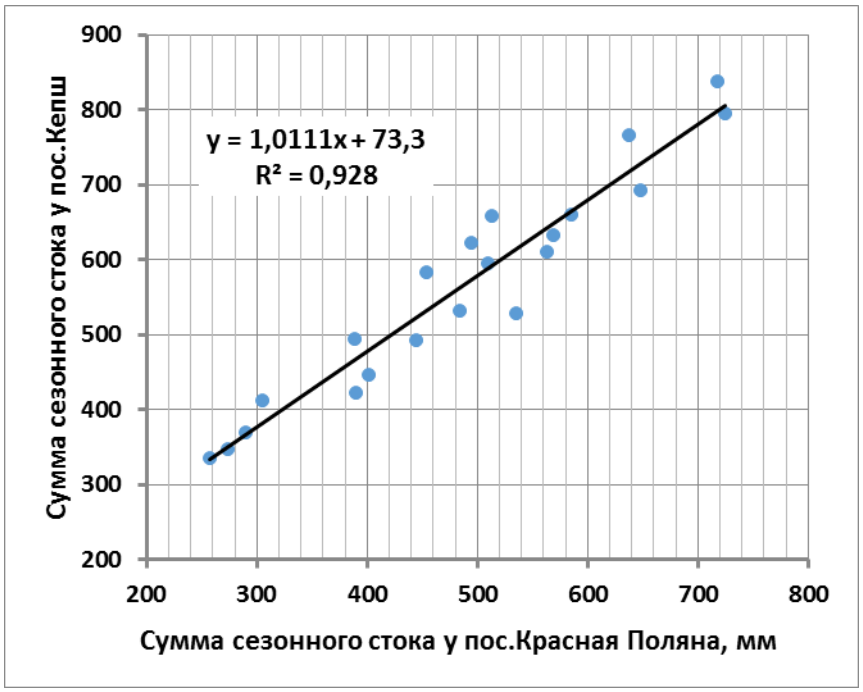

Рис. 33. График связи сезонного стока за холодный период р. Мзымта у пос. Красная Поляна и пос. Кепш, мм стока

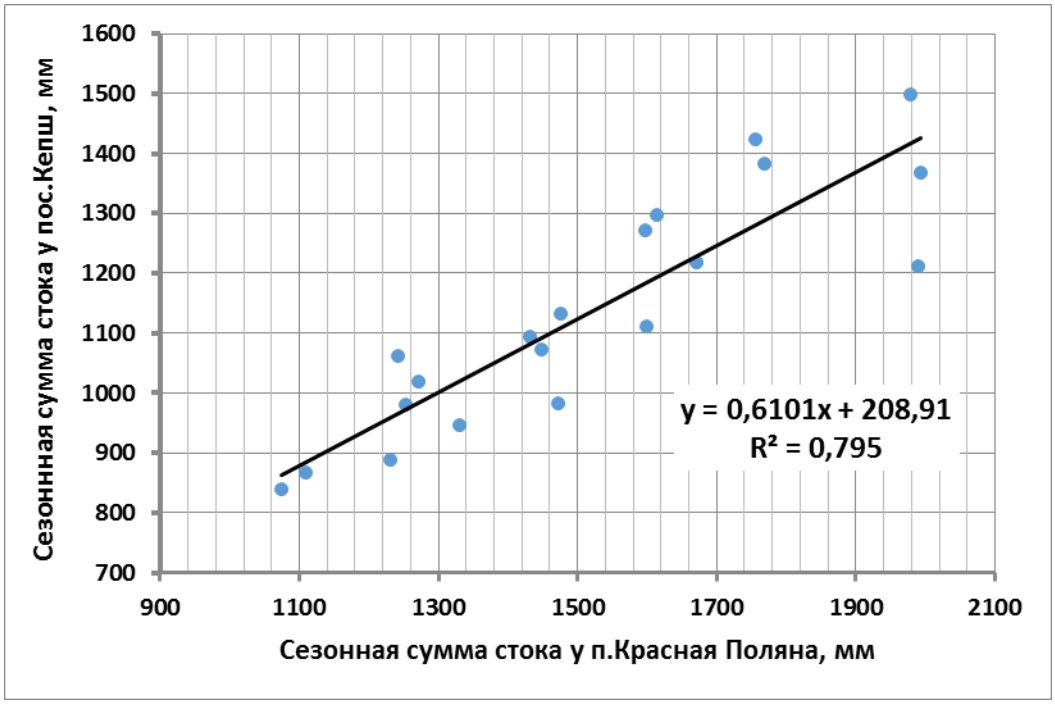

Рис. 34. График связи сезонных сумм стока р. Мзымта у пос. Красная Поляна и пос. Кепш за теплый сезон

Следует обратить внимание на высокую степень корреляции между сезонными суммами стока р. Мзымта у пос. Красная Поляна и у пос. Кепш – R^2 = .80-0.93) (Рисунок 33 и 34), что можно объяснить сходными условиями формирования стока на этой части водосбора реки.

Особенностями внутригодового режима стока в этой части водосбора реки Мзымта следует отметить превышение стока теплого периода над холодным сезоном практически в 2 раза, что объясняется наличием снегового питания реки.

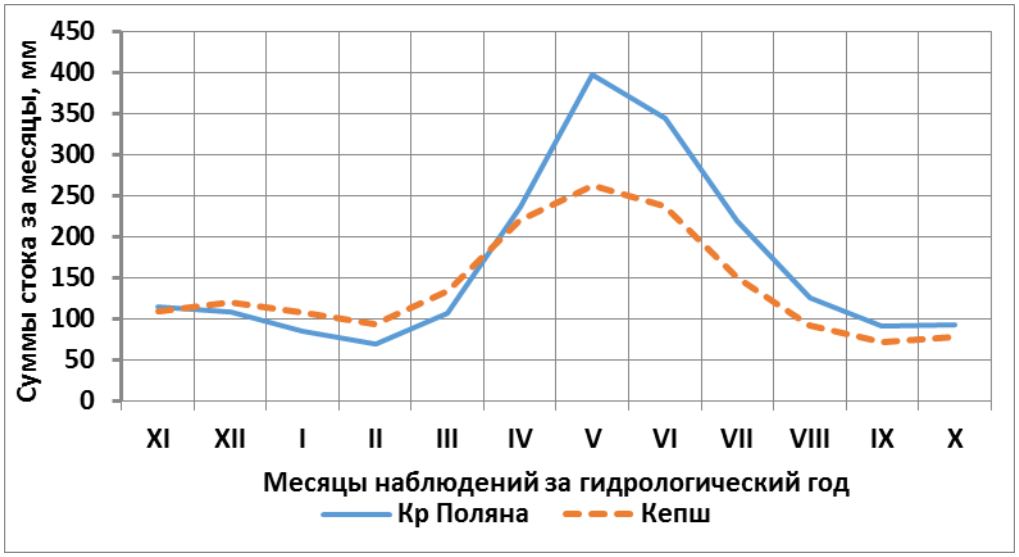

Рис. 35. Нормы месячного стока р. Мзымта у пос.Красная Поляна и пос. Кепш (средние за период 1946-1967 гг.)

Анализ режима стока реки Сочи у с. Пластунка и у г. Сочи. Как указывалось выше, период наблюдений на реке Сочи у с. Пластунка имеет наибольший ряд наблюдений (Рисунок 36). Из приведенного графика следует, что общая тенденция годового стока имеет отрицательный наклон, при этом сезонные суммы стока примерно одинаковы за холодный и теплый период.

Годы наблюдений 1930–1965 показывают повышенный сток р. Сочи, затем наблюдается спад стока в период , 1965–1977 гг. и далее следует повышение стока с 1978 по 2003 гг.

На Рисунке 37 приведен хронологический график годовых сумм стока реки Сочи у с. Пластунка и у г. Сочи за период параллельных наблюдений 1945-2005 гидр. годы.

Хронологический график изменения годовой суммы стока р. Сочи у с. Пластунка и г. Сочи за 1945–1991 гг. показан на Рисунке 38. Средние за период 1945–1991 гг. суммы стока р. Сочи у с. Пластунка =2095,5 мм, р. Сочи у г. Сочи – 1715,7 мм; разница в стоке составляет 380 мм за гидрологический год.

Хронологический график изменения сезонного стока р. Сочи у с. Пластунка и г. Сочи за холодный период в 1944–1991 гидрологические годы приведен на Рисунке 39. В среднем за 48 лет (1944–1991 гг.) сток р. Сочи у с. Пластунка равен 1029 м, а р. Сочи у г. Сочи – 868 мм за холодный период; разница 161 мм составляют в среднем потери стока за холодный сезон.

Хронологический график изменения сезонного стока р. Сочи у с. Пластунка и г. Сочи за теплый период в 1944–1991 гидрологические годы приведен на Рисунке 40. В среднем за этот период (1944–1991 гг.) сток р. Сочи у с. Пластунка равен 1067 мм, а р. Сочи у г. Сочи – 847 мм за теплый период. Разница за теплый сезон в среднем составляет потери стока 220 мм.

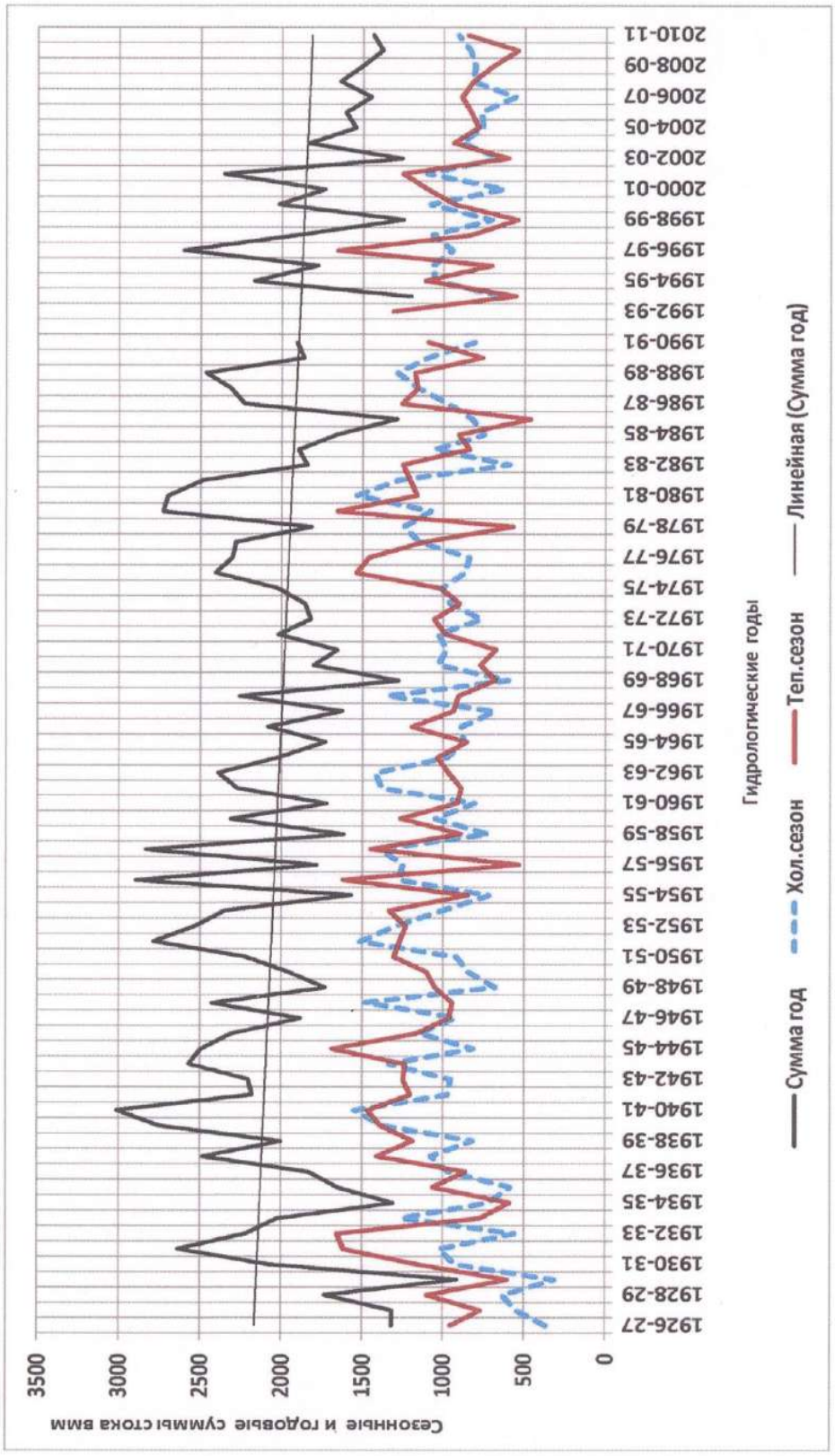

Рис. 36. Хронологический график годовых и сезонных сумм стока реки Сочи у с. Пластунка за период наблюдений 1926–2011 гидр. годы

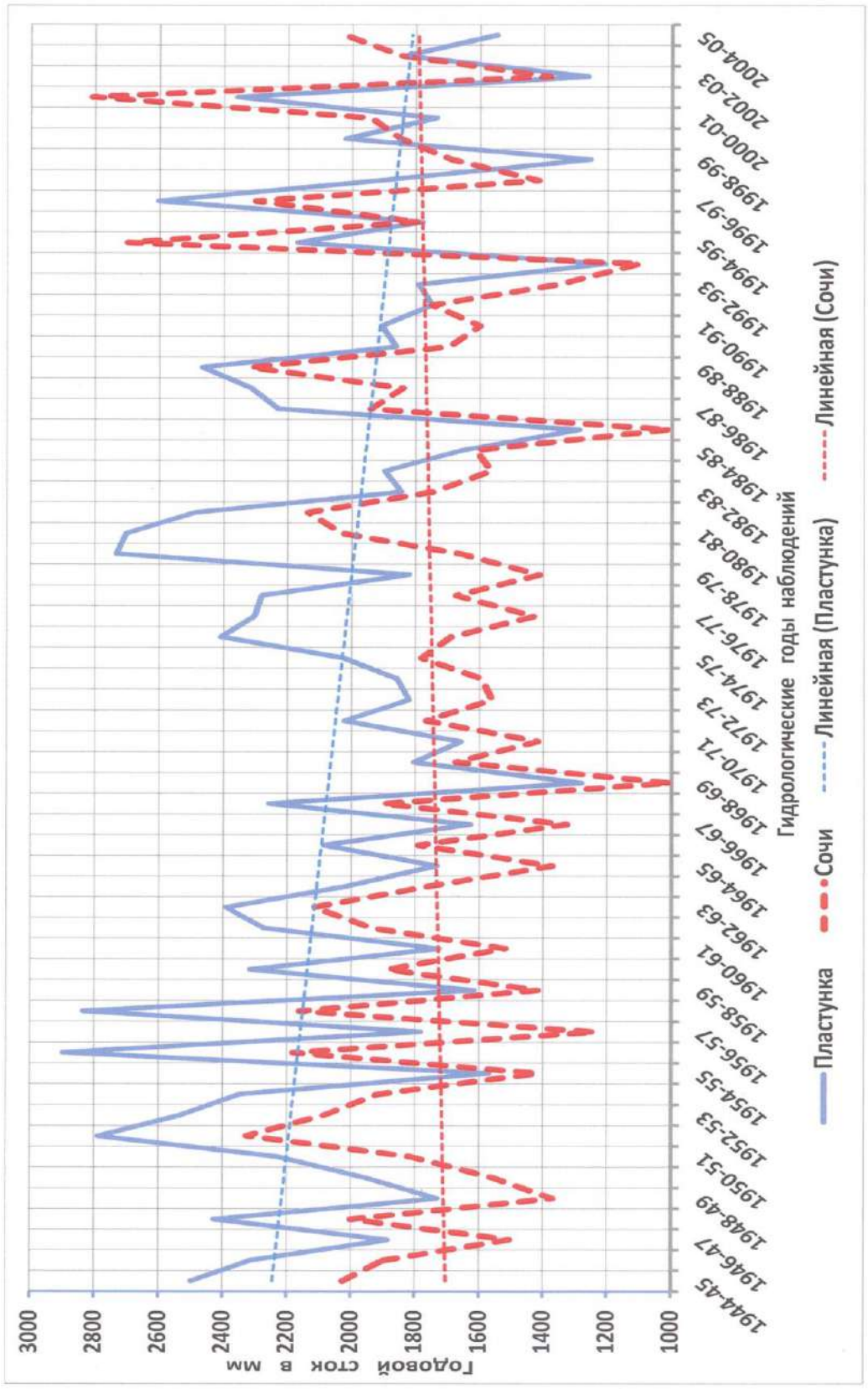

Рис. 37. Хронологический график изменения годового стока р. Сочи у с. Пластунка и р. Сочи у г. Сочи за 1945–2005 гидрологические годы

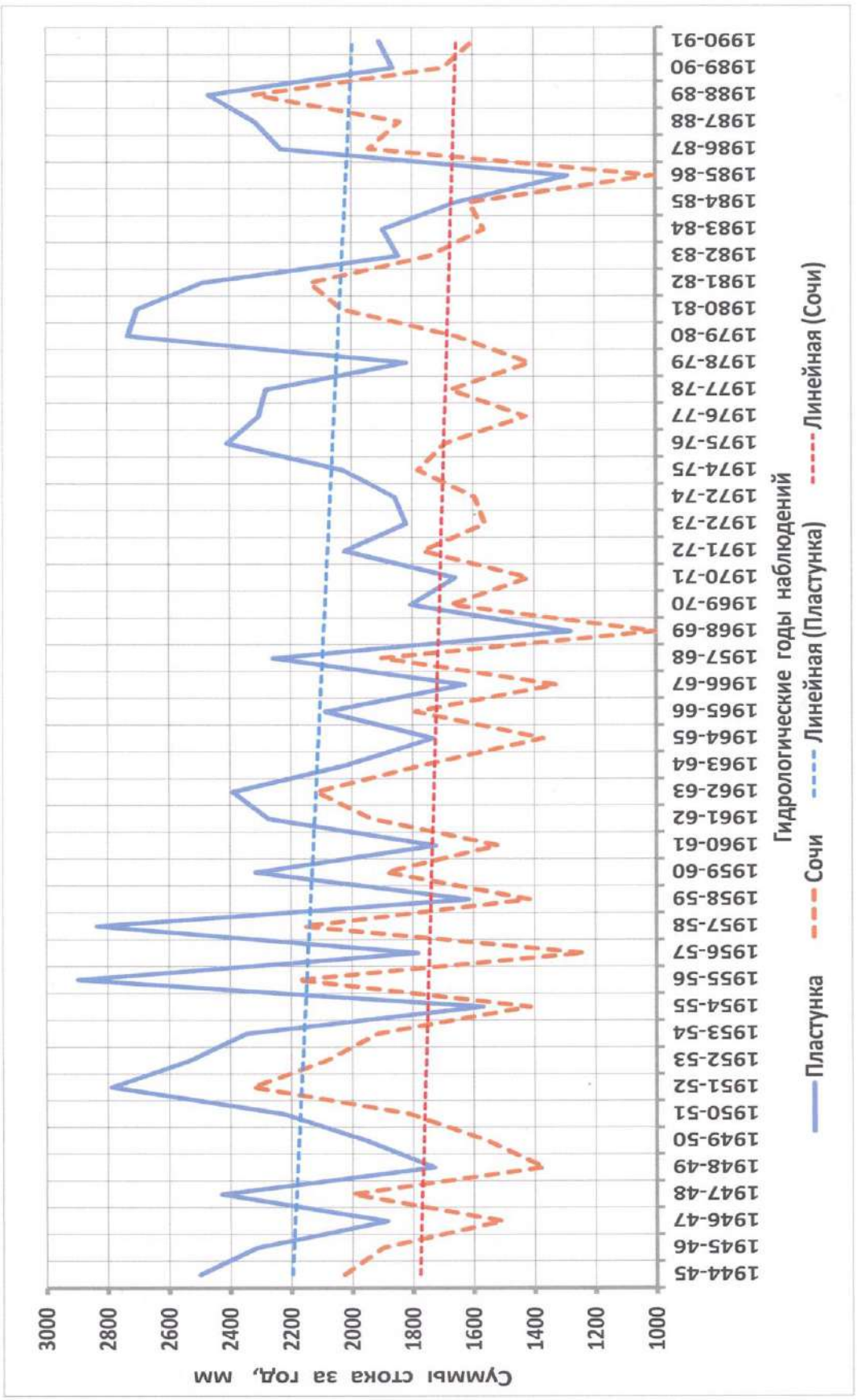

Рис. 38. Хронологический график изменения годового стока р. Сочи у с. Пластунка и р. Сочи у г. Сочи в 1945–1991 гидрологические годы

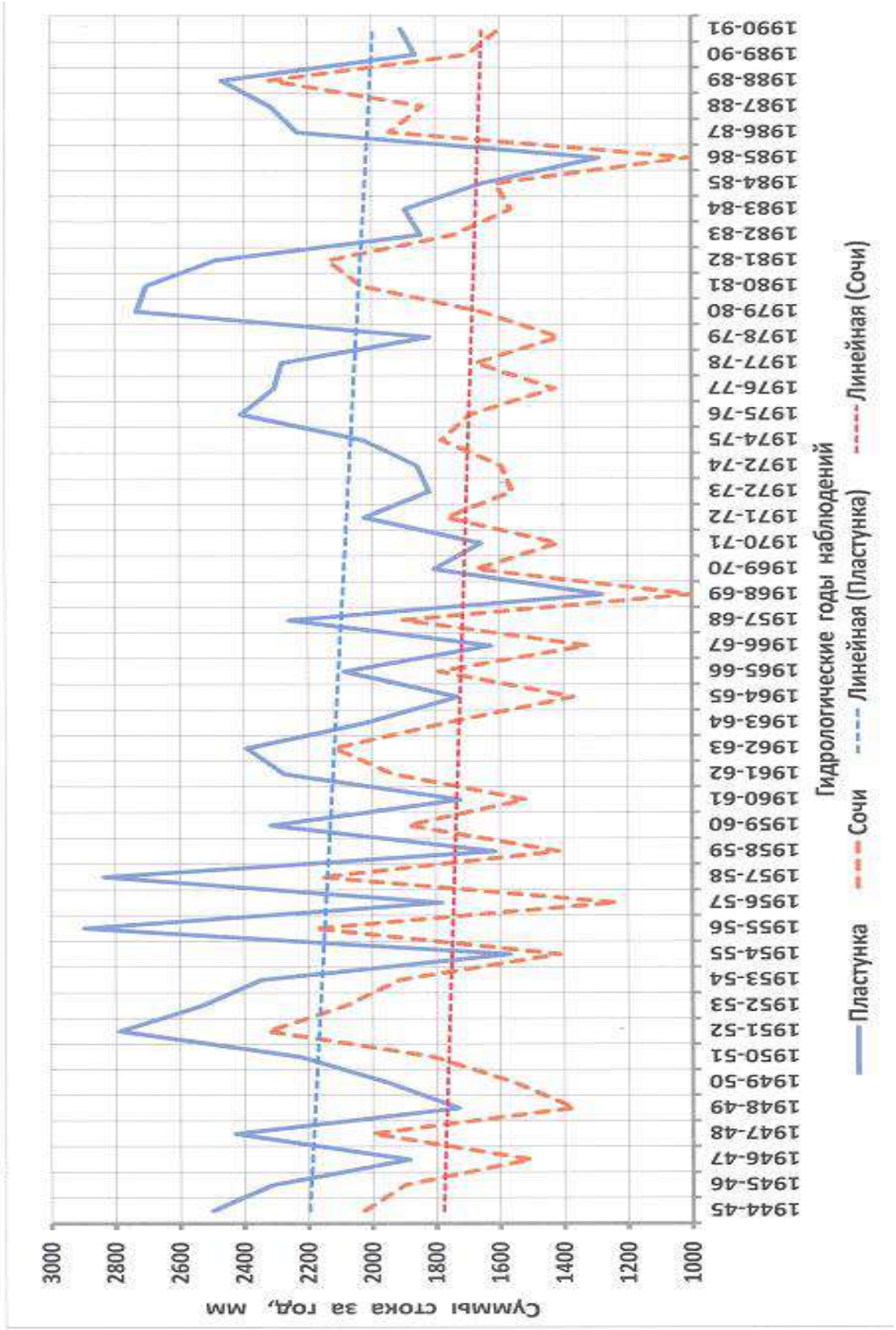

Рис. 39. Хронологический график изменения сезонного стока р. Сочи у с. Пластунка и г. Сочи за холодный период в 1945–1991 гидрологические годы

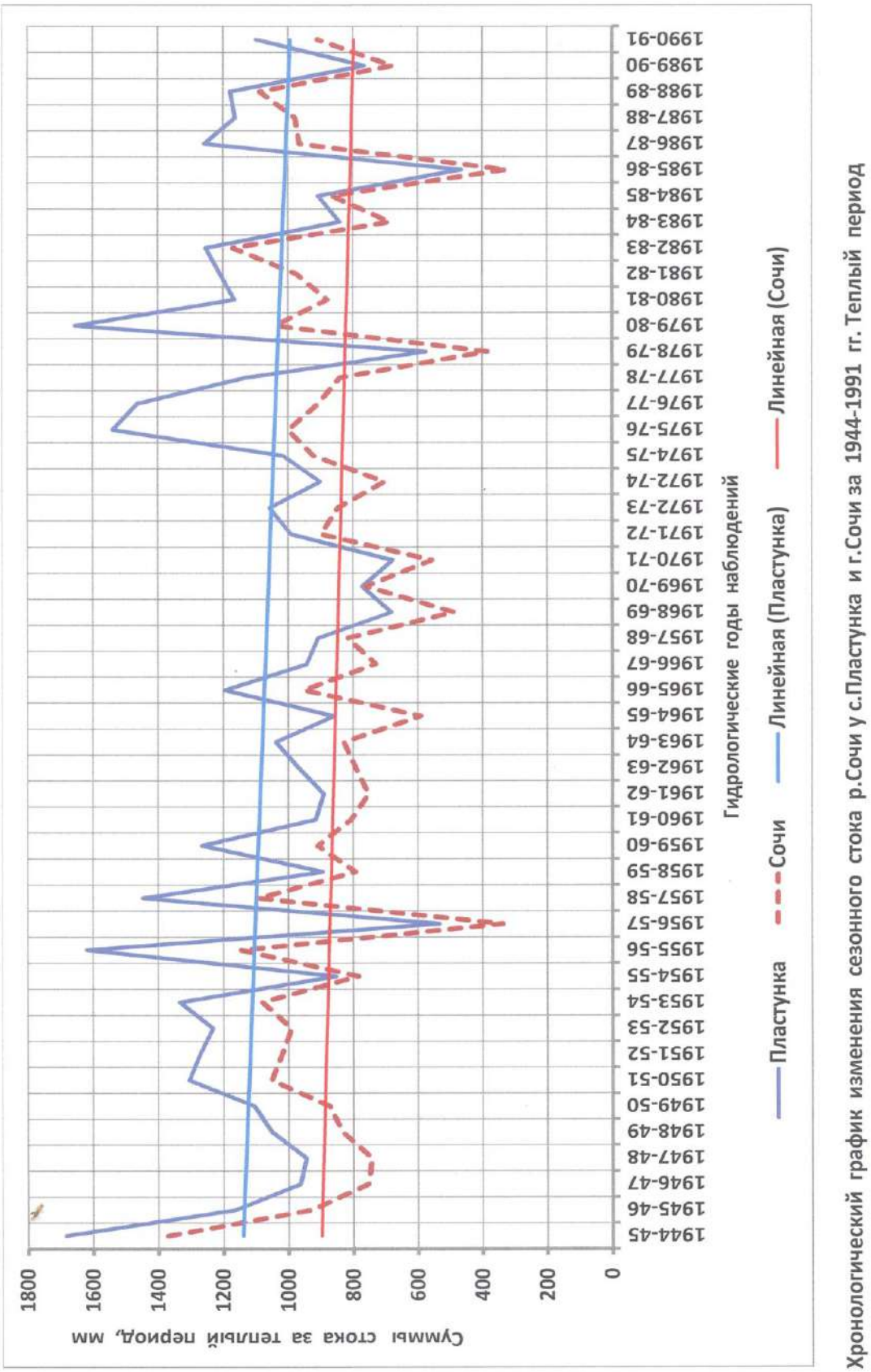

Рис. 40. Хронологический график изменения сезонного стока р. Сочи у с. Пластунка и р. Сочи у г. Сочи за теплый период в 1944–1991 гидрологические годы

Особый интерес представляет режим стока р. Сочи за последние 15 лет. На Рисунке 41 представлен график изменения годовых сумм стока р. Сочи, который показывает некоторое превышение годовых сумм стока в нижележащем гидростворе: среднее значение годовой суммы стока р. Сочи у г. Сочи составляет 1853 мм, а р. Сочи у с. Пластунка – 1801 мм.

Рис. 41. Хронологический график изменения годового стока р. Сочи у с. Пластунка и г. Сочи в 1991–2005 гидрологические годы

За холодный сезон график рис.42 также показывает некоторое превышение стока р. Сочи у г. Сочи (905 мм) над стоком у с. Пластунка – (886 мм), т.е. прибавка в стоке почти 20 мм.

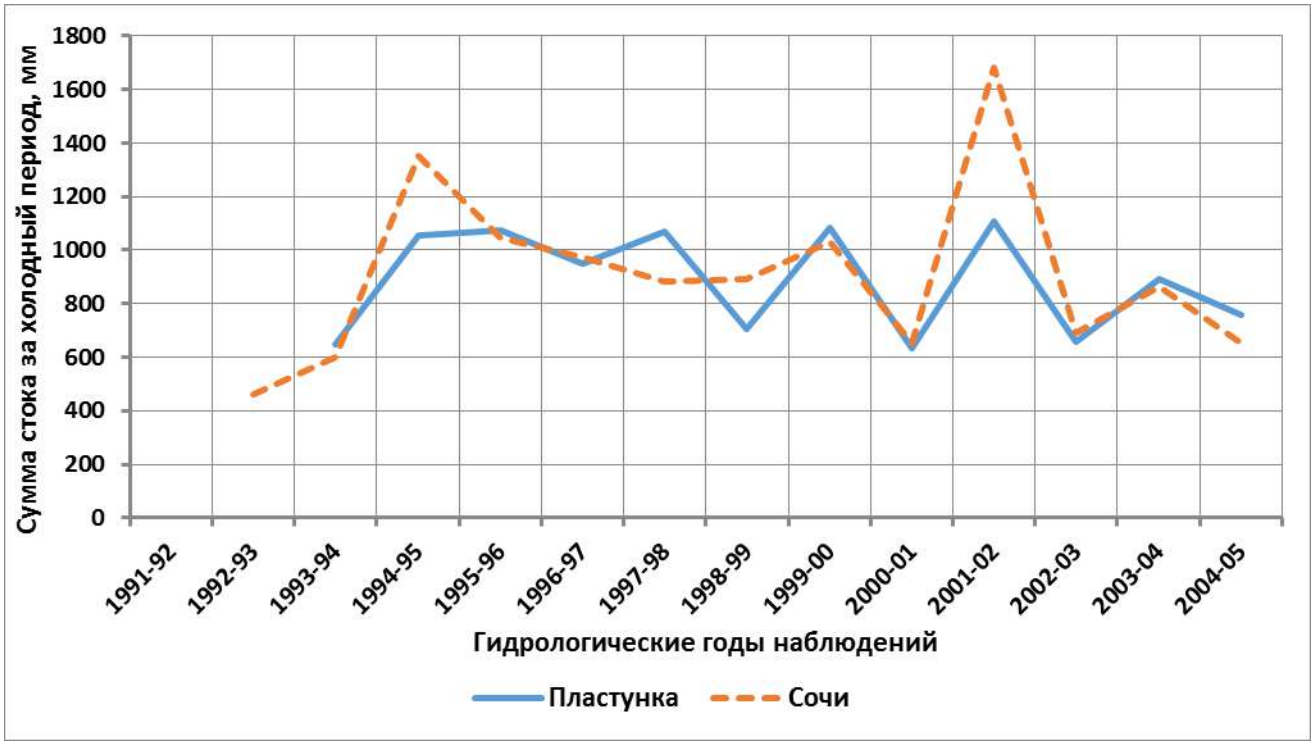

Рис. 42. Хронологический график изменения сезонного стока р. Сочи у с. Пластунка и г. Сочи за холодный период в 1991–2005 гидрологические годы.

Холодный период

Аналогичная картина наблюдается и в теплый сезон (Рисунок 43): средние за период наблюдений 1991–2005 гг. величины стока у с. Пластунка = 950 мм, у г. Сочи = 956 мм.

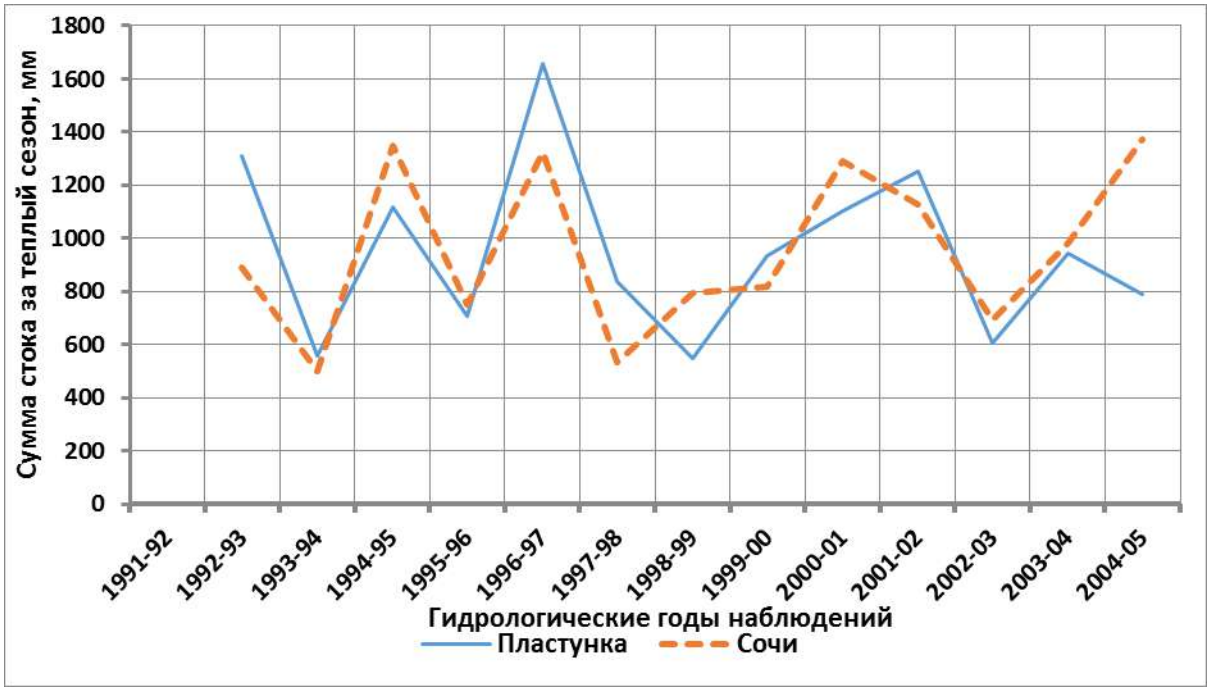

Рис. 43. Хронологический график изменения сезонного стока р. Сочи у с. Пластунка и г. Сочи за теплый период в 1991–2005 гидр. годы

На Рисунке 44 показана взаимосвязь сезонных сумм стока р. Сочи у с. Пластунка и у г. Сочи за период наблюдений 1944–1551 гг., которая характеризуется высокой степенью корреляции.

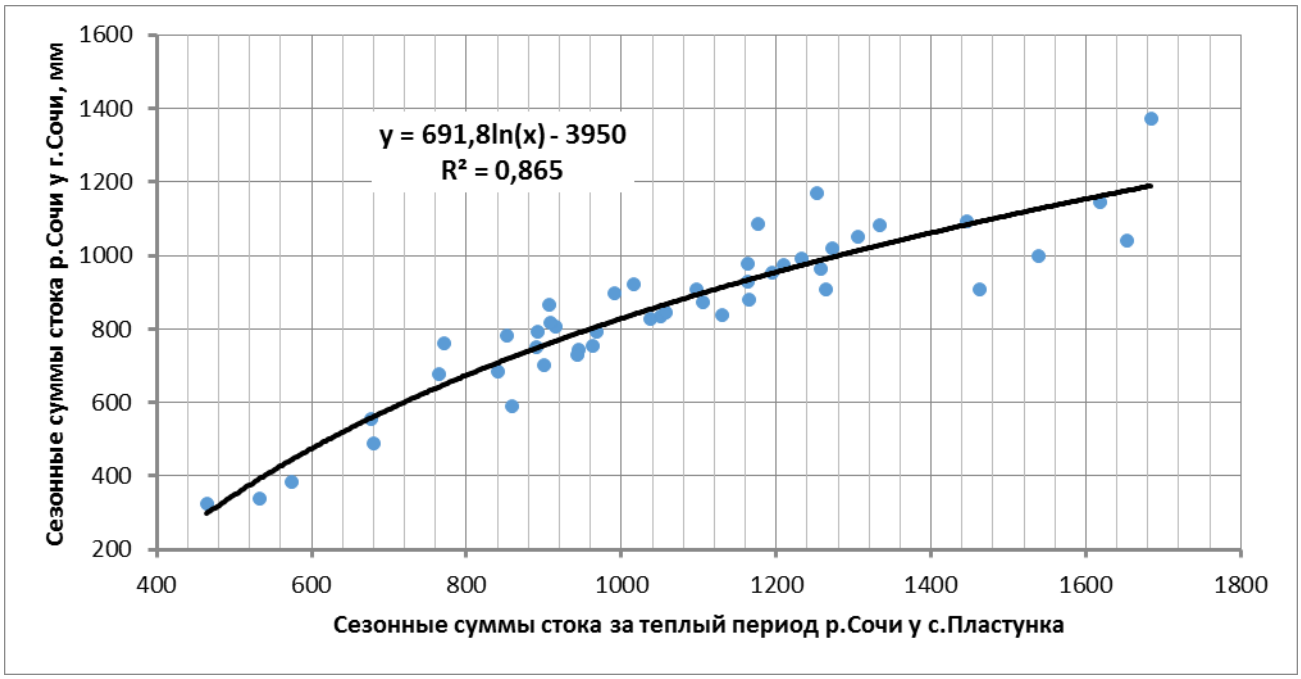

Рис. 44. Связь сезонных сумм стока р. Сочи у с. Пластунка и у г. Сочи за период наблюдений 1944–1991 гидр. годы

4. Заключение

1. В силу особенностей геоморфологического строения Сочинского Причерноморья основные реки территории (Псоу, Мзымта, Сочи, Шахе, Псезуапсе и Аше) имеют резко асимметричную форму бассейнов с преобладанием основной части водосбора в высокогорной и среднегорной части территории. Это оказывает влияние на водность рек, распределение стока внутри гидрологического года, на особенности питания рек и формирования стока по длине.

2. Измеренные величины норм стока в различных частях бассейнов рек в среднем имеют значения в пределах 1500-2100 мм за гидрологический год при измеренных на метеостанциях величинах норм осадков около 1400-2200 мм. Эти значения элементов водного баланса не могут характеризовать средний сток и осадки горных водосборов рек региона вследствие влиянии на климат высотной зональности территории.

3. Из перечисленных выше рек Сочинского Причерноморья только реки Псоу и Мзымта имеют соответственно 22 и 32 % территории бассейнов в высокогорной зоне (выше 1800 м НУМ), и 56 % – в среднегорной зоне (от 600 до 1800 м НУМ. Остальные водосборы в основном располагаются в среднегорной зоне – от 54 до 77 % площади бассейнов.

4. В связи с этим основной зоной формирования стока рек является высокогорная и среднегорная часть бассейнов рек. Так, река Мзымта в зимний период гидрологического года (с ноября по март) имеет минимальный сток, и увеличение стока в среднем в 2 раза в теплый сезон (с апреля по октябрь). Остальные реки региона в связи с преобладающим дождевым питанием характеризуются увеличенным стоком в холодный сезон.

5. На примере двух рек региона, имеющих наблюдения за стоком на протяжении реки (реки Мзымта и Сочи) проанализированы особенности формирования стока по длине рек. Из приведенных графиков изменения расходов воды и суммарных слоев стока следует, что наибольшая водность рек приходится в основном на среднее течение реки. Примерно одна треть длины рек, приходящаяся на низкогорную и пологохолмистую зоны в значительной мере теряют сток на формирование внутригалечного стока расширяющихся к устью долин рек.

6. Наиболее показательными в этом плане являются измерения стока на реке Сочи, которые дают нулевой прирост расходов воды с приустьевой 15-км части бассейна (прирост площади водосбора 58 км^2).

7. Расчеты среднего слоя стока по реке Мзымта дают уменьшение стока на участке Красная Поляна – Казачий Брод на 162 мм за гидрологический год, и на 300 мм – за теплый сезон.

8. Материалы наблюдений по реке Сочи за 48-летний период показывают потери стока на 15-км приустьевом участке в размерах 161 мм за холодный сезон, и 220 мм – за теплый период. При этом изменения условий формирования стока на этом участке водосбора, связанные с активным освоением территории, повлекшим увеличение коэффициента стока, несомненно сказываются на формировании речного стока территории.

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Особенности формирования гидрологического режима горных рек на территории сочинского Причерноморья

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Аннотация. Статья посвящена анализу формирования гидрологического режима горных рек Сочинского Причерноморья. В связи с особенностями геоморфологии и рельефа региона, а также климатическими условиями основной зоной формирования стока рек является высокогорная и среднегорная часть бассейнов рек. Так, река Мзымта в зимний период гидрологического года (с ноября по март) имеет минимальный сток, и увеличение стока в среднем в 2 раза в теплый сезон (с апреля по октябрь). Остальные реки региона в связи с преобладающим дождевым питанием характеризуются увеличенным стоком в холодный сезон.

На примере двух основных рек региона, имеющих наблюдения за стоком (реки Мзымта и Сочи) проанализированы особенности формирования стока по длине. Из графиков изменения расходов воды и суммарных слоев стока установлено, что наибольшая водность рек приходится на среднее течение реки. При этом треть длины рек, приходящаяся на низкогорную и пологохолмистую зоны в значительной мере теряет сток на формирование внутригалечного стока. Наиболее показательными в этом плане являются величины стока на реке Сочи, которые дают нулевой прирост расходов воды с приустьевой 15-км части бассейна (прирост площади водосбора 58 км²).

Ключевые слова: Сочинское Причерноморье, геоморфология Кавказа, речная сеть, бассейны рек Мзымта, Сочи, объемы стока, изменение стока рек по длине, гидрологический режим рек.

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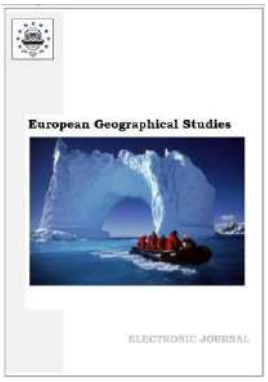

Natural and Social Characteristics of the Rural Settlement Vranještica: Geographical Overview

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Being in the field required me to examine and reassess large areas of my life: my traits, my intentions, how I thought about myself and how I related to others. Such self-reflexive contemplation led to substantive questions about the appropriateness of my actions and how I was conducting the process of fieldwork, paving the way for more thoughtful and concerned work, which served as a reminder that research should be more than an extractive activity (Chacko, 2004).

Abstract

The rural settlement of Vranještica is located in the northeastern part of Montenegro. It extends in the zone 42 ° 47´ 09 "north latitude and 19 ° 37´ 35" east longitude. Except for the road Andrijevica – Trešnjevik – Mateševo – Kolašin, no other important road intersects or touches this rural settlement. The spatial distribution of the studied space is determined by natural and social characteristics. The relief of Vranještica was formed mainly in the Tertiary. Thus, high mountains were created on one side, and hanging valleys and alluvial plains on the other. The greatest importance in terms of hydrography is represented by Vranještička River and Suvogorska River, which are still waiting for different possibilities of exploitation. With increasing altitude, the productive ability of the pedological composition decreases. Diverse flora and fauna have adapted to climatic, hydrographic and pedological conditions. When it comes to social characteristics, our research records highlighted several evident problems: the first is related to the population, ie its aging; others, that there is a pronounced migration of the population – whose intensive processes and stratification have left behind an unfavorable age structure of the population, which has all negatively affected the socio-economic development of the rural settlement of Vranjestica.

Keywords: rural settlement, Vranještica, natural characteristics, social characteristics, geographical overview.

1. Introduction

Although the social needs for research of rural settlements in our country are indisputable, we are not able to meet our own current and other needs in this area. In that respect, we lag behind most European and even neighboring countries. Thus, we confirm the clearly formulated position

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of Jaćimović (1985) "that this arises also because studies of large areas are more popular today, in which the problems of those smaller spatial units – rural settlements – cannot be seen at all. And there are problems (demographic, social and economic) in each of our villages, and some have been so transformed under the influence of urbanization and de-agrarianization, that over time they have lost their former agricultural function. These problems may arise from the general social attitude towards agriculture and its current state, with a lot of problems and insecurities, and hence, I guess, the underestimating attitude sometimes towards some work about only one, rural settlement?!". We hope that this will not be the case on this occasion.

The small number of relevant sources and the great lack of adequate (scientific and professional) literature have objectively had a limiting effect on the quantity, quality and degree of completeness of the treatment of the presented issues. Namely, there are only a few important scientific papers in which the rural settlement of Vranještica is mentioned only by the way. In that respect, we should mention Vešović (1935), Dašić (1986) ... Complex geographical researches of the rural settlement of Vranještica, relatively clearly individualized wholes, have not been conducted so far. Therefore, the rural settlement of Vranještica belongs to the underdeveloped rural settlements of the municipality of Kolašin, both in the economic and social sense. That is, it is a rural environment of hilly and mountainous character. Initiation of changes, which would lead the studied area to faster inclusion in the modern system of production, economy and way of life, was the main motive we were guided by when studying this rural settlement (Special inspiration for this text, author G.R. had for the following reasons: Vranještica. A village at the foot of Bjelasica. The village where my mother was born. That is where one part of my childhood remained, my carefree and happy days ... Where the sky has the most stars... Where the Suvogorska River has the most beautiful murmur ... Where Wellspring Kojov heals the soul... Where the meadows have the most beautiful flower ... Where the forests have the most beautiful shade... Where Katun Backo Brdo gives the greatest peace... Where blueberries are most delicious... Where the house of Miloš Kojov keeps the most beautiful memories and emotions that remain in my dreams to last forever ... That is where I belong. My mother's homeland is also my homeland).

Numerous studies confirm that without new jobs in rural areas, young people will not stay in the villages. Despite that, there are more and more organizations of young farmers at the local level, which advocate for greater participation in the development of settlements, that is, to earn approximately similar incomes for the same work as residents of urban areas, to have a better quality of life and working conditions. It is considered that generational renewal in the coming period should be an EU priority, while allowing flexibility for member states to design and develop tailored programs that reflect the specific needs of their young farmers, in terms of employment, education, opening kindergartens and health facilities, improving transport, water and sewerage infrastructure, in order to reduce the numerous risks to public health and safety of residents (European Commission, 2017).

2. Methodology

Citing research by Brown and Schafft (2011) ande Stambuk (1991) Klempić-Bogadi et al. (2015) emphasize that the definition of the concept of rurality can be approached with regard to two dominant approaches. According to the first, rurality is determined by the social and geographical characteristics of the area, above all population size, population density and/or the dominant type of production – in the first place agriculture. At the same time, rural settlements are almost always smaller and have lower population densities than urban ones, geographically and socially isolated from power centers predominantly located in urban areas, with a predominant natural environment as opposed to built-up urban space. The triangle village – agriculture – space forms the basis for defining rurality, rural world, rural society, rural space and all other synonyms that denote areas outside urban agglomerations, i.e. by breaking down the concept of rurality one can start from the country, continue with agriculture, conclude with landscape. So, the core of the methodological procedure used in this research is the geographical (spatial) method. The method of observation was supposed to provide insight into the social environment, using the following sources: oral, written, visual and biographical. Two methods were applied in the research explanation: analytical and synthetic. The first discusses the individual dimensions of the research subject, and the second the whole, the interrelationships between the research subject and the

proposed measures that arise from it (see Woods, 2012; Lescheva et al, 2014; Gaukhar et al., 2019; Bulatović, Rajović, 2021).

2. Analysis and discussion

The rural settlement of Vranještica is located in the northeastern part of Montenegro (Kolašin municipality). It extends in the zone 42 ° 47´ 09 "north latitude and 19 ° 37´ 35" east longitude. It borders the rural settlements of Rečine in the west, Gnjila Potok in the southeast and Bare Kraljske in the south. It is located at an altitude of 1519 m and covers an area of 2,480 hectares. In 2003, 152 inhabitants lived in this area.

The traffic-geographical position of the rural settlement of Vranjestica is unfavorable, because it is located far from the main roads. Except for the road Andrijevica – Trešnjevik – Mateševo – Kolašin, no other important road intersects or touches this rural settlement. Vranještica is 44.6 km from Berane, 29.6 km from Andrijevica and 11.2 km from Mateševo. Isolated traffic – geographical position adversely affects its economic and social development. The gravitational zone of Vranještica, seen from a spatial point of view, is not small, but the population is really small. Without greater economic potential in this settlement, there is no wider existential base of the population. Therefore, we should expect its further stagnation and emigration of the population to the developed parts of Montenegro or going abroad.

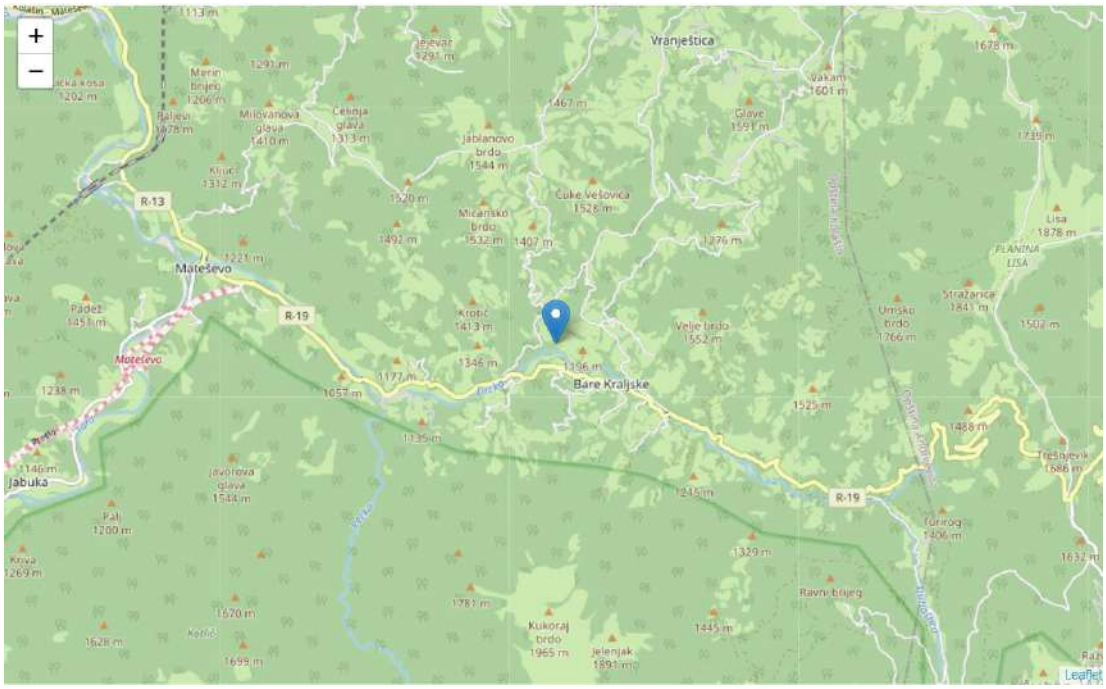

Fig. 1. Rural settlement Vranještica on google map (www.ekarta.me)

The relief of Vranještica was formed mainly in the Tertiary. Thus, high mountains were created on one side, and hanging valleys and alluvial plains on the other. The morphological feature of the relief is the appearance of karst, covered with humus, red soil, clay land and grove, which are used in agriculture. The flysch area is characterized by lush forest vegetation. The rocks of the Sarmatian period have favorable hydrogeological properties, which is the basis for settlement and agricultural activity. Quarterly alluvial and deluvial sediments are present in the river valleys of Vranještička River and Suvogorska River. Colluvial soils (colluvium) are exposed to leaching and belong to the group of autogenous undeveloped soils. Rendzina in the considered geo-area above 1,200 m above sea level is of limited fertility. Of the other lands, the following are represented: district brown lands in the Lisa area and district brown lands on eruptions (see Bulatović, Rajović, 2018).

Fig. 2. Rural settlement Vranještica
Note: if you have ever wondered what it looks like when winding green hills, mountain streams, unreal landscapes and very rare plant species come together - now is your chance to see it [*]

The geomorphological view of the studied area is dominated by the mountain Ključ (1,973 m above sea level). Some branches of Ključ: Krstac (1,770 m above sea level), Čkala (1,804 m above sea level), Klisura (1,827 m above sea level), Ćupovi (1,885 m above sea level), Goveđa glava (1,897 m above sea level) are watersheds between the Lim and Tara basins. The geographical position of the entire settlement gives it the characteristics of a mountain climate. So far, there have been no special climate tests in this settlement, as well as no precipitation measurements. However, individual observations of climatic elements of the Hydro meteorological Institute of Montenegro (2001) indicate the following amplitudes of air temperature: the maximum temperature during the summer can reach 34.1 ° C, and in winter it can drop to – 27.8 ° C. The warmest month is July, with an average air temperature of 14.9 ° C, and the coldest January, with an average temperature of 3.9 ° C. The average annual air temperature is around 5.2 ° C. Rain is frequent and abundant, most often formed by clouds above Bjelasica, Lisa and Trešnjevik. It should be noted that seemingly insignificant streams in the event of heavy rain caused real devastation and great damage to farmers. The period with snow can be long, usually from the beginning of November to March and April. Lately, snow has been falling more and more often in the month of May. Maximum precipitation occurs in the period from September to March. The average annual rainfall is 2105 mm. The maximum amount of precipitation is 318.5 mm in December, and the lowest amount of precipitation is in July and amounts to 65.9 mm. The north, south wind and a mixture of wind called "culprit" prevail. The highest relative humidity occurs in the winter and is about 90 %. The average annual cloudiness is 6.1 h. The maximum cloudiness is in December and is 7.4 hours, and the minimum in August is 4.1 hours. The average insolation annually amounts to about 167.4 h. It reaches its maximum in July (274.3 h) and the minimum in January (43.2 h).

[*] The photos in the text were taken from the Vranještica site, our home (www.facebook.com)

Fig. 3. Vranještička River
Note: Enchanting beauty where peace, silence and the laws of nature reign

The hydrographic network of the rural settlement of Vranještica consists of the Vranještička River and Suvogorska River with their flows. Vranještička River springs below the mountain Ključa (1973 m above sea level) formed by three streams (Rastoka, Provalije and Taljigovina). The length of River is about 9.2 km. Suvogorska River springs below the mountain Lisa, which in its source part consists of two streams Odrtog and Zimovnik. The length of the river is about 4.3 km. VranještičkaRiver and Suvogorska River meet in Međuriječje and flow into the geo-area of the rural settlement of Bare Kraljske in Drcka River. The waters of the Vranještička River and Suvogorska River and their tributaries are suitable for irrigating agricultural areas. To supply the rural settlement, several independent sources are used. The springs are quite abundant, they almost do not dry out, and the water is cold and very pleasant to drink. Among them we single out: Vučićev Wellspring, Paljevine, Livadak, Ledni Wellspring, Kojovića Wellspring, Zejov Wellspring, Ivanovića Wellspring...

In addition to plant crops on the territory of the rural settlement of Vranještica (corn, rye, barley, oats ...), fruits (apples, plums, pears, cherries, walnuts ...), vegetables (potatoes, cabbage, onions, green beans, cucumbers, salads). ...), there are also forest fruits (strawberry, blueberry, raspberry, blackberry ...), medicinal herbs (St. John's worth, mint, thyme ...), mushrooms (porcini, spruce ...). Among domestic animals are grown mainly: cattle, sheep, goats, chickens ... On the territory of the studied area there are katuns: Bačko Brdo, Lisački Katun, Vukićeva Staja, Krivi Do, Katunište ... In the mountainous hinterland, a variety of game has found its habitat: bears, wolves, deer, chamois, wild boar, rabbits, grouse, partridges, wild ducks, eagles ... In Vranještička River and Suvogorska River live fish – trout. The mentioned living world lets us know that there are extraordinary conditions for the development of hunting tourism.

Fig. 4. Agricultural plot
Note: Potato growing (Vranjestički potatoes – the most famous potato in Montenegro).

The forest vegetation of the rural settlement of Vranještica is difficult to single out. This is primarily a consequence of climate and general ecological changes in the past (tertiary) and the natural effort of plant communities to adapt to changes and preserve them. It is the lowest belt of alluvial plains of Vranještička River and Suvogorska River, represented by hydrophilic forests of willows and poplars (Sallcon Albae), alder (Alnion Glutinesae) ... Then follows the forest belt of oak (Auercetum frainetto ceris), beech and beech – fir forests (Fagion moss). Some mountainsides of this rural settlement are made up of pine forest stands. The basic orientation is to increase the area, ensure permanent and more economical production of wood mass, rational use and increase growth.

Fig. 5. Bukova Poljana (Church Lazarica)
Note: Where nature and history, culture and art, value and tradition meet

Throughout the historical past, the rural settlement of Vranjestica has often changed its role both culturally and economically. Until the Second World War, the most attention was paid to cattle breeding and agriculture. A large amount of wool was used for the production of bedding and clothes, and sheepskin and cowhide for footwear. The quality of meat products was enviable, conditioned by various pastures and mountain meadows. Both livestock and agriculture developed at the level of personal needs of the household. After the Second World War, Vranještica had opportunities and needs for change: a primary school was built, a library was formed, a large number of modern residential buildings were built, then shop, many hamlets were connected by local roads ... Through personal work and contribution, electricit ... However, after 1961 in Montenegro, as well as in the whole of the former Yugoslavia, there was industrialization and accelerated development of cities. This is the reason why the population of the settlement emigrated to the economically developed centers of the former Yugoslavia or to temporary work abroad. Based on field research, it was concluded that economic measures were delayed. It was the beginning of the seventies of the last century a turning point. If it had started in that period with a small economy, construction of roads, faster electrification of settlements, today Vranještica would not have provided the usual picture of the majority of underdeveloped rural settlements in Montenegro (see Bulatović, Rajović, 2020).

Fig. 6. View of the northeastern part of Vranještica
Note: A combination of mystical energy and magnificent nature

The analysis of the above points to the conclusion that the motives for leaving this rural settlement were multiple. We will reduce them to the most important ones, in our opinion:

Provision of conditions for non-agricultural production in which higher productive work could be achieved, and thus higher and more stable income. Regardless of whether it is a labor or intensive economic activity, the company, naturally, within its capabilities provides the necessary means of production and other working conditions that allow the employee to permanently employ his labor force for which such opportunities on individual farms, in most cases , does not have;

Existential security, which arises from a high degree of certainty that by engaging in non-agricultural activities, income-means of subsistence is achieved. In agricultural production, there is uncertainty on individual property, which is still subject to the influence of external factors, both in terms of yielding certain crops and the prices at which they will market their products, which together leads to significant oscillations in the amount of income. Due to that, there is a fear in the security of providing material conditions for maintaining one's own existence; by joining the

employment, the individual agricultural producer, on that basis, acquires the right to health care (himself and his family), as well as conditions for retirement, which is an important element of social security.

General living conditions in the city provide far greater opportunities for education and cultural life, full health care and other benefits that the city has, compared to the countryside, which is a significant motive for migration or emigration, especially of young people (Bulatović, Rajović, 2021).

The following data indicate the demographic picture of the rural settlement. Compared to 1948, the number of inhabitants in 2003 decreased by 322. The largest decrease was recorded in the period from 1961 to 2003 (the number of inhabitants decreased by 341). In the period from 1991 to 2003, the decrease in population was 87. Based on field observations of Stamena Miloševa Račić (married Rajović), 89 inhabitants lived in the considered geo-space in 2012. From this data, it follows that the total number of inhabitants in the settlement decreased in the period 1948 – 2012 by 81.2 % (385 inhabitants). Observing the data from the 2003 census, it is noticed that the population is in the process of demographic aging. There are 131 adults living in the rural settlement, and the average age of the population is 49.5 years (46.5 for men and 52.8 for women). There are 57 households in the settlement, and the average number of members per household is 2.67. In the field in 2012, we noticed a large number of elderly households and households with one member each. For example, in a settlement there are 9 households with one member each, while there are 11 households with two members each. The decline in the total population, caused by emigration and depopulation, have become the basic demographic problems of this rural settlement Vranještica (see Rajović, Bulatović, 2016; Bulatović, Rajović, 2020).

Our research records based on similar research by Rajović and Rajović (2010) indicate the following:

Rural settlement Vranjestica has favorable conditions for livestock development. Within animal husbandry, especially those branches should be developed for which there are special quality conditions. Natural conditions favor sheep breeding as the main – cattle breeding, and then cattle breeding with a significant increase in the head to the optimum, which is determined in cooperation with other branches. Reclamation of pastures would improve the conditions for cattle breeding. In that sense, it is necessary to develop projects for the establishment of meadows and amelioration of pastures. Establishment of meadows refers to appropriate agro-technical works with the basic goal of forage yield. Pasture reclamation refers to agro-technical works related to clearing the terrain, fertilizing and sprinkling grass seeds. By intensifying hay production, by applying agro-technical measures (irrigation, fertilization of meadows and pastures ...), the number of sheep and cattle can be significantly increased.

Fig. 7. Beekeeping in Vranještičkom geo-space (Vranještički meadow honey)
Note: There is no greater joy than when you collect honey and give it to your loved ones to sweeten and enjoy

Considering the natural conditions of the settlement and the shortage of labor, in the near future the priority should be to stimulate the production of beef, primarily by increasing the livestock of breeds suitable for grazing, i.e. by seasonal fattening of young cattle to a certain weight.

Within this framework, the accompanying production of cow's milk can be successfully developed, i.e. sheep breeding is mainly oriented to the market production of lamb. The chance of the rural settlement of Vranještica is in the untapped possibilities of extensive cattle breeding. First, here we mean the project of forming sheep and cow farms. In addition to construction works, the procurement of appropriate equipment, agricultural machinery intended for the production and preparation of animal feed, as well as the procurement of a part of the basic stock (breeding cows and bulls, sheep and rams), whose reproduction would gradually replace the existing castles. Such households could then produce cheeses and other dairy products according to the obtained standardized technology, with specific packaging. Over time, a sign or even a health food label could protect the products (see Rajović, Bulatović, 2012).

Fig. 8. Meadows surrounded by forest complexes
Note: A real gift of nature

Fig. 9. A flock of sheep
Note: A rare picture, unfortunately in the Vranještičkom geo-space

Successful operation of such mini farms implies perfect organization and coordination, and in any case the existence of centers for milk, cheese ... "collection" character. The location of sheep and cattle farms, if we add pig and goat and other farms is determined by the natural conditions and the stability of the population in this rural settlement. In that sense, it would be necessary to study the analysis of the specifics of rural settlements in Montenegro, from the aspect of construction and location of mini farms, as well as the type of livestock production, then recommended capacities and examining the possibilities of cooperative production for larger capacities.

A very applicable concept and idea of fish production, primarily trout, is also interesting for the rural settlement of Vranještica. The settlement is extremely rich in water: Vranještička River, Suvogorska River, Wellhead (recorded 126), Mountain Streams (recorded 36) ... The hydrographic network indicates that there are extraordinary conditions for the development of small fishpond along Vranještička River, Suvogorska River and their tributaries. As a limiting factor, we should keep in mind the changing water level, then the danger of turbidity, because as it is known, it is torrential water. In essence, it should be stated that the village is extremely suitable for mini fishpond, which, like mini farms, should be examined by a special study, determine their possible number, then the results that can be expected and other important parameters (Bulatović, Rajović, 2020).

There are very favorable conditions for farming in the settlement, which means the expansion of areas under vegetables. On very modestly represented arable lands, with the application of larger amounts of manure, the introduction of appropriate crop rotations and better tillage, higher production of potatoes and fodder cereals can be achieved. In the rural settlement of Vranještica, in addition, appropriate measures are to be taken to stop the declining trend of arable land, by increasing the level of equipment of households with modern machinery, especially for the production, transport and conservation of roughage. The implementation of the consolidation program, in order to eliminate the current state of high fragmentation and fragmentation of arable land, is also one of the conditions for the recovery of farming. Fruit growing would be done on all suitable plots, with the basic condition of providing efficient traffic connections, fast transport of very sensitive products. Due to the differentiation of natural conditions, intensifying sheep and cattle production can achieve optimization in the exploitation of production potential. It is necessary to do a study and investigate the suitability of areas for the production of medicinal herbs. However, an abundance of various medicinal plants has been noticed, which could be imposed by organized production and cultivation as a profitable branch of farming – the cultivation of industrial plants.

Fig. 10. Wild strawberries
Note: A gift of nature, are not only a delicious dessert, but are also used as a medicine, and the sweetness of wild strawberries is indispensable on the table of the Vranještičkog geo-space

As it could be noticed earlier, the forests on the territory of Vranještica have always been either an integral part of the property and the backyard, or the immediate hinterland, i.e. the source of materials, shelter, refuge, climate regulator, micro locations ... As a large present element of life, forests will be a significant spatial component in future trends in the development of the economy and construction policy. In the future treatment of forests, a larger volume of felling or some other action that would be contrary to eco-agriculture and ecotourism should not be allowed. The volume of felling should be adjusted to the condition of growing groups within the appropriate class of forests, in order to ensure wood mass on one side, and preservation of forest quality on the other. Due to the efficiency of planting, it is necessary to afforest purely forest terrains, especially those created after felling. Therefore, erosive areas and other unstable soils should be afforested as a preventive measure to protect the soil. The volume of felling should not be increased, and the actions should be directed to sanitary felling, in the maximum volume. In general, forestry should be integrated with eco-agricultural development. Analyzes would probably show that forests could provide multiple incomes in the eco-agricultural concept compared to conventional management (Bulatović et al., 2019).

Fig. 11. Forests Vranještica
Note: Green oases of peace and quiet

In the rural settlement of Vranjestica, hunting should be viewed as an activity on the line of demarcation between eco-agriculture and forestry and ecotourism. Special attention should be paid to the constant care that the game in the mountainous hinterland of the village is well fed and fed in winter, so that it can develop properly and reproduce naturally. The basic investment recommendations in hunting refer to investment investments in landscaping and improvement (feeding grounds for hairy and feathered game ...), as well as investment investments in comfortable waiting rooms (for hunting in winter conditions and wolf hunting).

Fig. 12. Eagle crusaders
Note: Lords of the sky over rural settlement Vranještica

Suitable physical-geographical factors, and above all the abundance of water, provide opportunities for the rural settlement of Vranjestica to develop into one of the most attractive tourist villages in the municipality of Kolasin, i.e. Montenegro. Several preconditions for this concept are necessary: the exceptional natural beauty of this rural settlement and orientation to eco-agriculture, i.e. ecotourism, would increase the quality and specificity of the tourist offer (here would require some education of hosts and organizers of eco-agriculture in terms of emphasizing certain elements of the offer). Relying on the administrative center Kolašin, in organizational, marketing and financial terms, with the help of obtaining clientele (which is demanding in terms of landscape exclusivity, requires proximity to peaks, special natural sites, peace and not many tourists, and not demanding in search of high comfort). An even more special type of tourist offer, which is completely imbued with agricultural development, is ecotourism agricultural farms. Tourism is a secondary part of the business here, complementary to the basic production.

Fig. 13. Municipality of Kolasin
Note: A chance in the development of rural settlement

If we take into account the natural conditions and projections of agricultural development in the rural settlement of Vranjestica, we can see the possibility of developing ecotourism and agricultural farms: sheep, cattle, goat breeding, and horse breeding and for breeding and selection of hunting dogs. If the ecotourism character of production is built into investing in mini farms, the interest of farmers and investors increases by several possible, and mostly economic-social aspects. Revenue is significantly increased, by introducing exclusivity, with a minimum of additional labor invested. Increasing communications for the population, by bringing tourists into the agricultural environment. Mutual cultural and educational activities of farmers – hosts and tourists, on each other. Removal and release of the farmer and his family from loneliness, isolation, which has been proven by research to be unfavorable for the participants in agricultural production.

Partial increase of investments in additional accommodation facilities, which are not always significant in terms of volume, are reduced to a reasonable and realistic measure, when we take into account: Existence of infrastructure next to the house (water, electricity, somewhere and sewage ...); The usual household chores are already being done, with now more attractive in front of the audience, and food preparation is already being done (extension of this obligation is a stimulus for the housewife and a chance for her even contribution to the household) (Bulatović et al., 2019).

Weaknesses and problems faced by rural areas in Montenegro are demographic in nature, which is reflected in the intensive depopulation of rural settlements and unemployment. Migrations, negative natural increase, small and elderly households are the image of the Montenegrin village. There are also numerous infrastructure problems. However, the biggest problem that rural agriculture faces is the lack or outdated agricultural mechanization, fragmented property, abandoned land. Lack of financial resources for reconstruction, capacity expansion, inability to obtain favorable loans are problems that characterize agriculture and rural tourism. The weakness of the village is insufficient processing capacities that are no longer in function, and used to be an integral part of cooperatives, which no longer exist. The largest number of cooperatives represented the bearers of the development not only of agriculture, but also of the entire rural economy. The purchase of agricultural products is usually insufficiently organized. There is no contracted agricultural production, nor support to producers during production ... (see Petrović, Grujović, 2015).

Therefore, Zakić and Stojanović (2008) rightly conclude that a successful rural development policy is considered to be one that achieves the following goals, ie enables certain rural areas to:

- maintain their population and the vital structure within it;
- diversify their economic base outside the primary sector by maintaining, or even increasing, employment rates in order to absorb surplus labor in the primary sector;
- equalize rural and urban poverty and unemployment rates in an effort to provide priority employment for women and youth;
- have as easy access as possible to basic services that make life in rural areas more attractive;
- expand property-ownership structures by initiating the establishment of small and medium-sized enterprises on the basis of local financing;
- maintain the physical and mental health of the rural population at the same level as outside rural areas;
- the main actors of the area work together to achieve common goals on the basis of an agreed value system created according to a bottom-up approach;
- responsible for their own development not expecting someone else to do it for them. Greater employment of young people in the place of residence and the establishment of their families would revitalize villages and all other small settlements in Montenegro, including Vranještica. According to Lukić (2016), such an endeavor requires a change in the economic structure of the village, which implies action in two basic directions: (1) improvement of agricultural production and business of private companies, (2) development of small and medium enterprises in crafts, industry and various types of production services tailored to the villagers.

3. Conclusion

The traffic-geographical position of the rural settlement of Vranjestica is unfavorable, because it is located far from the main roads. The gravitational zone, seen from the spatial point of view, is not small, but it is from the population point of view. The depopulation of the population, together with the strong process of demographic transition, slowed down the further demographic, social, economic and general social development of this rural settlement. That is why it is necessary to take a number of social measures for the revitalization of the settlement. Among the most important are: the development of agriculture and tourism. We are of the opinion that with the activation of the entire community, some progress is not only possible, but must be achieved. Historical experience shows that rural settlements gave the city the best people, demographically increased and refreshed them, in the villages, positive character traits, love for traditional values, customs, habits, tastes are kept and respected for the longest time ... In the economic-geographical analysis, it is not always easy to distinguish to what extent the objectively present limiting conditions (mountainous character of the settlement) participate in the missed opportunities, and to what extent they must be attributed to insufficient or inadequate economic organization and incomplete information (see Bulatović, Rajović, 2020). Previous economic development programs did not take into account specific geographical conditions, so they could not give adequate results. In the end, the economic problems of the rural settlement of Vranjestica should be viewed realistically, without excessive optimism, and even less pessimism. According to Petrović and Grujović (2015) the goal of the development of rural areas is their revitalization, which requires large financial resources. The difference in the development of urban and rural areas is a consequence of economic

policy after the Second World War, where agriculture was neglected at the expense of industry. Experiences of developed and developing countries indicate that the development of rural areas is achieved through the development of non-agricultural activities that are intertwined with agriculture. Serious and active support of the state and local self-government is needed, along with incentive measures that will give the expected effects in agriculture and rural tourism.

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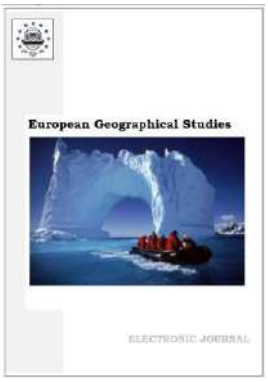

Pollution of Kvemo Kartli Region (Georgia) Soils by Heavy Metals

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Abstract

The expedition works were held in the territory of the Madneuli enterprise of Kvemo Kartli region in 2020, where brown soils are spread. In order to study the migration of heavy metals in the soil, taking into consideration the wind direction, the samples of soil was taken from 0-100 (0-10, 10-20, 20-40, 40-60, 60-80, 80-100) cm depths, in North from the source of pollution direction (Background) – weak winds direction, 500 m from the enterprise and in the direction of a strong wind in the West and 300 m from the enterprise. In the soil samples were determined general forms of heavy metals Cu, Zn, Pb, Mn, Ni, Cd, Co, As, Ag, Cr, Fe by Plasma-emission spectrometer at ICP-OES.

The quality of some heavy metal contamination of soil is revealed in connection with Clark; In contaminated areas, the relatively high concentrations of heavy metals are observed in the upper layers, which are due to the prevailing winds. in the samples taken from the north (background-weakest wind direction) heavy metal content were less. Specifically, from the background and contaminated areas the copper content with 0-10 cm layer 63.22 (1.4) and 324.13 (6.9) mg/kg; 80-100 cm depth decreases copper content and is 22.15 and 156.17 (3.3) mg/kg. Similar situation is in case of zinc.

Migration of heavy metals is reduced by increasing depth and approximately 1-5 times exceeding the relevant background importance.

In the samples taken from the background areas, some metals (cadmium, arsenic and silver) are high content, which is due to their existence in the soils of the region. At the same time, it is noteworthy that their Clark indicator is low and therefore 0.13; 1.7 and 0.07, which leads to increasing the Ratio concentration of these metals in relation to Clark.

As it appears from the data, the soil meets in the categories of copper, zinc and arsenic in the category of slightest pollution (<10) category; In cadmium and silver cases – in average pollution (10-30); And the concentrations of lead, manganese, nickel, cobalt and chromium do not exceed Clark.

Correlation links are investigated between the concentrations of different metals in the upper layers of the soil. The correlation coefficient is the largest between Cu and Zn concentrations. It is positive and equals 0.77, determination Coefficient (R^2) is 0.58 among the Cu-Zn concentrations. Correlation coefficient between Cu and Co concentrations are 0,62, determination coefficient of Cu-Co concentrations is 0.38. In all other cases the correlation coefficient is negligible and can be neglected.

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Keywords: Soil, heavy metals, pollution, concentration, correlation.

1. Introduction

In general, one of the most important sources of technological contaminants is mining enterprises that can play a negative role in environmental pollution processes and therefore it can be the risk factor in relation to the population's health.

For example in Georgia (Kvemo Kartli), in the Bolnisi municipality, is operating the polymetal mining enterprise in the south-east of Tbilisi.

Madneuli sulfide deposit is presented mainly in three types of ores – gold-copper-colachal, gold-barit-polymetal and gold-quartzit, which is processed by the flotation method (Gaphrindashvili et al., 2004). The works are carried out in an open career. This method is very cheap and profitable, but it can cause an environment, namely, the forests can be destroyed, the soils can be polluted and biodiversity. Priority pollutants of Madneuli enterprise are heavy metals – Cu, Zn, Pb, Mn, Ni, Cd etc, in particular it can occure in the environmental facilities in natural waters (Gvakharia et al., 1997, Shavliashvili et al., 2017) in soils (Vodyanitsky, 2017; Urushadze et al., 2007, Bakradze et al., 2018, Vodyanitsky, 2013, Khubutia, 2004) and therefore in food products. There is a threat to not only to the environment of the region, but also the health of the population and certain cities.

2. Materials and methods

Chemical analyzes were conducted in the accredited laboratory of the atmospheric air, water and soil analysis of the Environmental Pollution Monitoring Department of the National Environmental Agency of the ministry of Environment Protection and Agriculture of Georgia. For analysis, high tech equipment are used (soil depletion – Milestone – Start D Microwave System; pH meters-Milwaukee-mi 150; Plasma-emission spectrometer-ICP-OES and others). All stages of the monitoring is in accordance with the standards of the International Organization (ISO).

Features and statistical purposes of correlation coefficients between different metals concentrations are assessed by stiudent criteria:

$$t = \frac{r}{\sqrt{1-r^2}}\sqrt{n-2} \sim t_{n-2}$$

Where the R-correlation is a coefficient, and n-observations. If the stiudent parameter exceeds its critical importance at a specified level, or it is considered that the correlation coefficient is noteable, and if the criterion of Stiudent is less than its critical importance, then the correlation coefficient is not considered statistically and may be neglected.

3. Discussion

Wind rose of the Bolnisi municipality according to statistical materials of the Hydrometeorology Department of the National Environment Agency.

As shown in the Bolnisi municipality, the windshields of the West and the East in the Bolnisi municipality are less than the southern direction winds, and the winds of the north are negligible. Therefore, we have selected places where the most powerful is Western (contaminated) and North (Wallpaper) – weak wind directions.

It should be noted that as a result of drilling-explosive works on Madneuli deposit, large amount of can dust occures in the air, along with various heavy metals content, which can affect the territories of the villages, as well as the dust particles by the wind can distribute by long distances (about 30 km) and they are absorbted in the soil. In addition, at the place of ore is located Oreking devices and alkal squeres. Ore transportation is being carried out by cars which can cause Bypass roads pollution of Kazreti and can create additional dust. The dust content in the air is especially large in the summer season. Gold and copper mining enterprise works in continuous mode and frequency of dust separation from the enterprise depends on the intensity of explosions. The dust contains a large number of different kinds of harmful substances, including heavy metals that can be in the air. After some time they can be precipitated on the surface of the soil and can migrate in

deep layers of soil. Thus, the high background content of heavy metals in the can increase in different depths.

Brown (Cambisoli) soils are widespread in study areas (Urushadze, 1997). In order to study the migration of heavy metals in the soil, taking into consideration the wind direction, the samples 0-100 (0-10, 10-20, 20-40, 40-60, 60-80, 80-100) cm depths, from the source of pollution In the direction of GPS N41°26'35 ", E-44°35'55 " (background), 500 m from the quarry to the N-41°22'60 ", E-44°23'42 " (contaminated) carrier 300 m (once in a year). In The soil samples were determined general form of heavy metals (Fomin, Fomin, 2001).

In Table 1 is given the background concentracions of heavy metals in contaminated areas of the soil depth 0-100 cm in June 2020.

We have compared the concentrations of heavy metals with the corresponding Clark (Bogdanov et al., 2013, Supatashvili, 2009) (Table 1). It is worth mentioning that all metal content is high in the upper layers and their concentration decreases in the depths.

Copper in the soil, moves to organic masses and minerals and will be binded by them. As a result, it is hardly shifted to the deep layers of soil and it is possible to appear in a small amount in groundwater. As the results of the analysis show from the background and contaminated (ore) place, the copper content in accordance with 0-10 cm layer 63.22 (1.4) and 324.13 (6.9) mg/kg; 80-100 cm depth decreases copper content and is 22.15 and 156.17 (3.3) mg/kg.

Zinc's background concentracions does not exceed the Clark value at any depth, and at the door – 0-10 cm depth is 376.27 (4.5) mg/kg; 80-100 cm depth decreases its concentration and equals – 231.32 (2.8) mg/kg.

Table 1. Determine heavy metals in the soil 0-100 cm in depth, June, 2020

№	location	pH	Cu	Zn	Pb	Mn	Ni	Cd	Co	As	Ag	Cr	Fe
			mg/kg										%
1	background 0-10 cm	7	63,22/1.4	71.51	16.17	624.68	17.39	2.25/17.3	8.36	15.13/8.9	1.16/16.6	6.79	1.32
2	---„--- 10-20 cm	7.2	57.45/1.2	62.42	9.42	497.25	16.25	2.04/15.7	8.06	11.63/6.8	1.05/15.0	6.60	1.21
3	---„--- 20-40 cm	7.5	39.21	53.40	5.43	443.61	15.17	1.88/14.5	7.45	10.27/6.0	0.96/13.7	5.15	1.19
4	---„--- 40-60 cm	7.4	39.12	51.66	3.11	389.78	14.12	1.51/11.6	6.34	9.86/5.8	0.55/7.9	5.12	1.05
5	---„--- 60-80 cm	7.6	27.78	49.35	1.56	365.43	13.27	1.15/8.9	5.44	7.77/4.6	0.25/3.6	4.81	0.94
6	---„--- 80-100 cm	7.7	22.15	42.16	1.23	347.75	12.82	0.45/3.5	4.27	4.91/2.9	0.10/1.4	4.28	0.56

7	Near the mining 0-10 cm	7.2	324.13/6.9	376.27/4.5	18.14	712.33	19.53	3.06/23.5	10.64	17.65/10.4	1.89/27.0	10.72	1.77
8	---„--- 10-20 cm	7.4	288.62/6.1	323.41/3.9	16.78	591.41	18.60	2.75/21.2	9.86	15.88/9.3	1.75/25.0	9.54	1.28
9	---„--- 20 40 cm	7.3	185.65/4.0	333.17/4.0	15.18	555.48	16.48	2.21/17.0	9.52	15.47/9.1	1.52/21.7	8.23	0.95
10	---„--- 40-60 cm	7.3	261.87/5.6	272.11/3.3	13.26	432.27	15.24	1.88/14.5	7.17	13.56/8.0	1.33/19.0	6.65	0.81
11	---„--- 60-80 cm	7.5	192.21/4.1	247.05/3.0	8.11	422.49	14.66	1.56/12.0	5.44	8.21/4.8	1.20/17.1	4.68	0.60
12	---„--- 80-100 cm	7.6	156.17/3.3	231.32/2.8	5.46	402.72	13.18	1.32/10.2	3.19	5.31/3.1	0.54/7.7	4.47	0.44
Clarks-Clarks of elements of the Earth's crust according to Vinogradov			**47**	**83**	**16**	**1000**	**58**	**0.13**	**18**	**1.7**	**0.07**	**83**	**3**

It should be mentioned the high content of some metal (cadmium, arsenic and silver) in the samples taken from the background was observed, which is naturally in the region's soils. At the same time, it is noteworthy that their Clark indicator is low 0.13; 1.7 and 0.07, which leads to increasing the concentration of these metals in relation to Clark. In particular, the cadmium content in the background is 2.25 (17.3) and career – 3.06 (23.5) mg/kg 0-10 cm depth, and in the depths of 80-100 cm depth, its concentration is reduced to 0.45 (3.5) and 1.32 (10.2) mg/kg.

There is a similar situation in case of arsenic. Its content varies in the background ranges 15.13 (8.9) – 4.91 (2.9) to the entire depth of the mg/kg of the profile and 17.65 (10.4) – 5.31 (3.1) within mg/kg. While silver in the upper horizon of the background plot is 1.16 (16.6) mg/kg, gradually decreases in the depths and 80-100 cm is 0.10 (1.4) mg/kg; And near carier – 1.89 (27.0) – 0.54 (7.7) mg/kg.

Concentrations of lead, manganese, nickel, cobalt and chromium are not exceeding the values of Clark.

Element concentracions were compered with Clarks. The soil is considered a slightly contaminated, if the ratio is less than 10; On average, if the ratio varies from 10-30 pongs and strongly contaminated, if this size exceeds 30 (Gvasalia, 2014).

As it appears from the data, the soil meets in the categories of copper, zinc and arsenic in the category of slightest pollution (<10) category; In cadmium and silver cases – in average pollution (10-30); And the concentrations of lead, manganese, nickel, cobalt and chromium do not exceed Clark.

Below are the concentrations of heavy metals mg/kg, and the ratio of Clark.

Figures 1-5 show change in heavy metals concentrations of soil (0-100 cm depth) and is comparable to Clarks's. As shown from the figures, background indicators in the case of copper, zinc and cadmium are much less than a career (contaminated). Their maximum concentrations are recorded at 0-10, 10-20 and 20-40 cm depths. According to our opinion, this is due to the intimidated wind And severe metals accumulation and migration in the upper layers of soils. Their concentration is minimal in 80-100 cm depth. In the case of silver and arsenic, high concentrations of these metals in the background area, as mentioned, are due to their relatively high content in the region's soils.

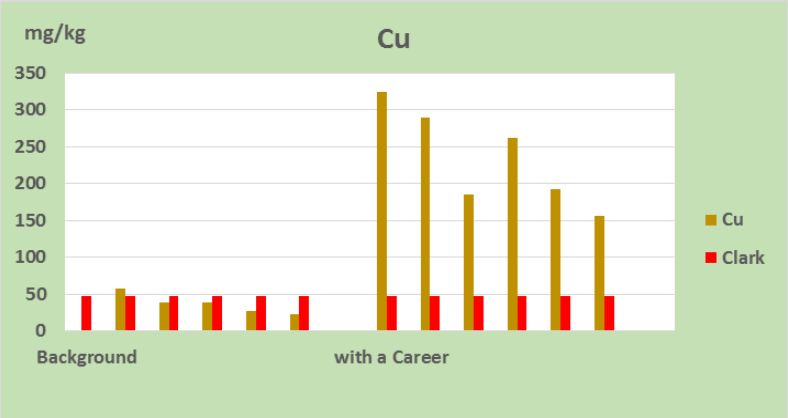

Fig.1. Copper concentration change in the soil 0-100 cm depth, 2020

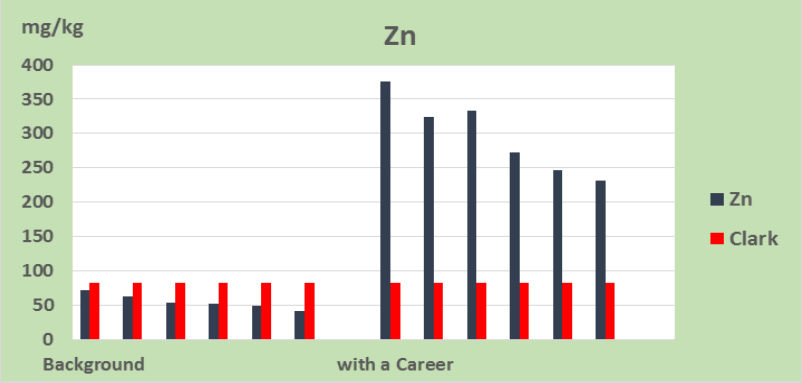

Fig. 2. Change of zinc concentration in the soil 0-100 cm depth, 2020

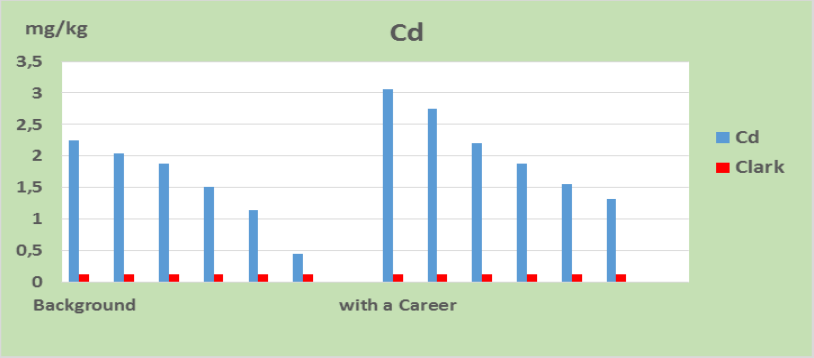

Fig. 3. Change of cadmium concentration Soil 0-100 cm depth, 2020

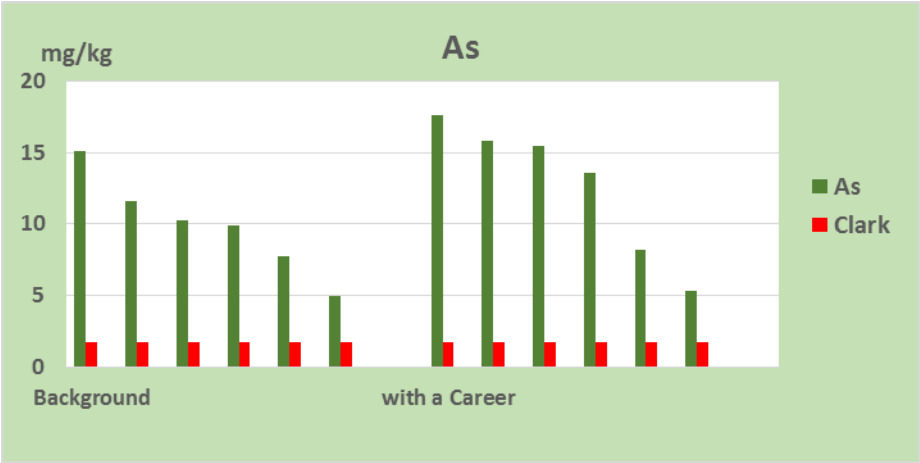

Fig. 4. Change of arsenic concentration Soil 0-100 cm depth, 2020

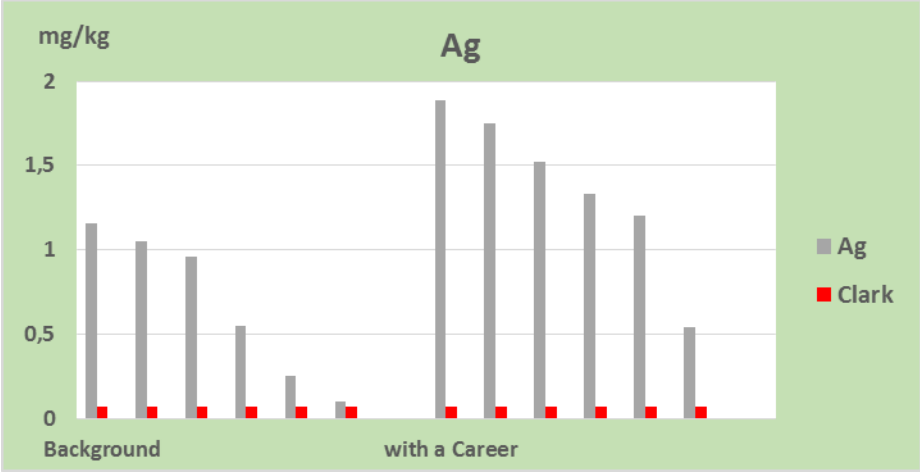

Fig. 5. Change of silver concentration Soil 0-100 cm depth, 2020

Figures 6, 7 show change in the concentrations of heavy metals in the soil 0-100 cm depth in 2020, where it is clear that high concentrations of heavy metals are marked in the upper layers of soil and in the background areas as well and near cariers.

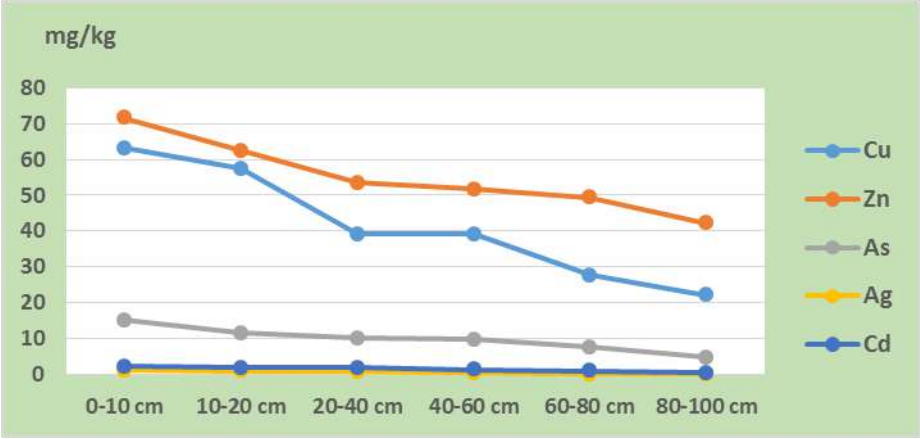

Fig. 6. Change of heavy metals concentration in the soil profile in background locations, June 2020

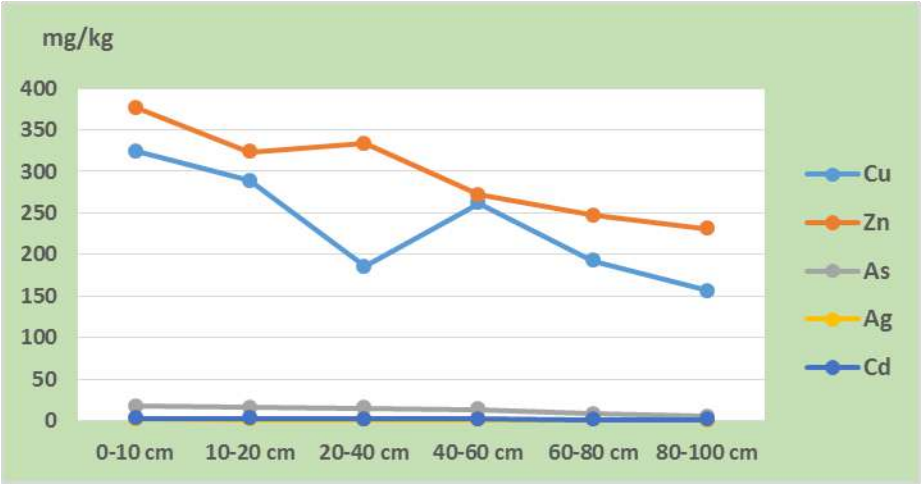

Fig. 7. Change of heavy metals concentration in the soil profile of the Career, June 2020

Correlation connections between the concentrations of different metals were investigated for the top layers of soil. The results are in correlated matrix (Table 2).

Table 2. Correlation matrix

	Cu	Zn	Pb	Cd	Co
Cu	1	0,77	-0.12	0.016	0.62
Zn	0,77	1	0.098	-0.57	0.26
Pb	-0.12	0.098	1	-0.10	0.28
Cd	0.016	-0.57	-0.10	1	0.45
Co	0.62	0.26	-0.28	0.45	1
Sample amount	10	10	10	10	10

Table 2 shows that the correlation coefficient is the largest between Cu and Zn concentrations. It is positive and equals 0.77, the connection between these two elements is directly proportionate and high; There is also positive and high correlation between Cu and Co concentrations and are 0,62.

That's the two couples Cu-Zn, and Cu-Co, meets Stiudents criteria $P < 0.05$. In all other cases the correlation coefficient is negligible and can be neglected.

The Determination Coefficient (R^2) is 0.58 among the Cu-Zn concentrations, which means that Zn's concentracion change 58 % is due to Cu-concentracion change. The determination coefficient of Cu-Co concentrations is 0.38, which means that the change of Co 38 % is due to Cu-changes.

4. Conclusion

1. In the polluted areas of Bolnisi municipality, on the basis of 0-100 cm depth, the analysis of samples revealed the relatively high concentrations of heavy metals in the upper soil layers, which is due to the prevailing wind through the factory of heavy metals and accumulated in the soil. And the northern (wind-weak, wind direction) areas in the samples heavy metals were much less content.
2. Migration of heavy metals in the soil samples taken from the baseline and contaminated place is reduced by increasing depth and approximately 1-5 times exceeding the relevant background importance.
3. The quality of soil pollution is established in connection with Clark. As it appears from the data, the soil is in a small pollutant category due to copper, zinc and arsenic; The content of cadmium and silver is especially distinguished from the metals, which are significant in the background locations. In terms of pollution they are in medium pollution category. And the lead,

manganese, nickel, cobalt and chromium concentrations do not exceed Clark indicators and there is no soil contamination with these elements.

4. Correlation connections are investigated between the concentrations of different metals in the upper layers of the soil. The correlation coefficient is a noted between Cu and Zn, and Cu and Co concentrations.

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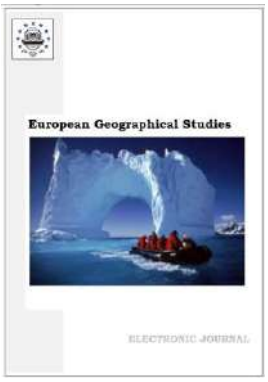

Ecological Condition of the Rioni River

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Abstract

Water resources are one of the most important natural resources of Georgia. Rioni River Imereti is a main artery of water. It is a left tributary of the largest river Imereti hills – Kvirila, which is connected with Dzirula Chherimeloy, and the right side connects with the waters of the Rioni Tskhenistskali. Rioni water used in production, and communal services the population. On both sides of the Rioni are large industrial facilities that degrade water quality. The problem of water resources protection Imereti and rational use of it, on the one hand has created increasing demand for water by industry, and on the other side of reservoirs pollution. Water pollution in the Rioni begins with the origins. From traditional polluting facilities should be noted Kvaisskoe, Tutiyskoe businesses, a lot of Oni and Ambrolauri businesses that poured on the raw water in the Rioni. And the most polluted river in the territory of Kutaisi.

Keywords: climate, energy, Imereti, Water, Rioni, Alazani.

1. Introduction

Georgia is a country in the Caucasus region of Eurasia. Located at the crossroads of Western Asia and Eastern Europe, it is bounded to the west by the Black Sea, to the north by Russia, to the south by Turkey and Armenia, and to the southeast by Azerbaijan.

Georgia's territory is divided in two main regions: Black sea basin and Caspian Sea basin. Total natural river runoff from the territory of Georgia is 56.4 km^3 and to the territory (from Armenia and Turkey) – 8.74 km^3 (Elizbarashvili, 2017). Thus, total water supplies amount for 65.4 km^3.

The biggest river in Georgia is Rioni which annual runoff is 12.6 km^3. There are large rivers in Western Georgia like Inguri (5.9 km^3), Chorohi (8.9 km^3), Kodori (4.1 km^3), Supsa (1.4 km^3), Bzib (3.0 km^3) and others. In Eastern Georgia there are Kura (7.2 km^3), Alazani (3.1 km^3), Aragvi (1.4 km^3), Big Liahvi (1.4 km^3), Khrami (1.0 km^3), Lori (0.8 km^3) and others.

Major issues are surface water pollution by wastes and irrational water use. Water pollution is connected with human activity. It comes from point and non-point sources.

Point sources:

1. Municipal wastes from cities and settlements.
2. Industrial wastes.
3. Wastes from hospitals, recreation and other health centers.

Non-point sources:

1. Surface wastes from agricultural fields.
2. Storm runoff from cities and landfills.

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1. Municipal wastes from cities and settlements pollute water with organic matters, nitrogen and phosphorus compounds. Most polluted rivers are Kura, Vere, Alazani, Algeti, Suramula (Caspian Sea basin) and Rioni (Black sea basin).

2. Industrial wastes bring oil products, phenols, heavy metals, etc.

Most polluted rivers in the Kura basin are:

- Kura within Tbilisi and Rustavi (oil products, phenols, heavy metals);
- Mashavera (zinc and copper ions).

In the Black sea basin:

- Kvirila (oil products and manganese ions);
- Rioni and its tributary Ogaskura (oil products, zinc and copper ions);
- Tkibuli (mechanical pollution from coal mining industry);
- Kubiszkali (oil products);
- Luhumi (arsenic ion).

3. Presently, serious problem is water treatment from hospitals, recreation and other health centers.

4. Agricultural wastes bring mineral fertilizers and pesticides. Major water consumer is irrigated farming. According to data of 1987, there were 469.2 th.ha of irrigated lands including 409.2 th.ha in Eastern Georgia (Kura basin) and 60 th.ha in its Western part (Black sea basin).

In 90-ies due to political and economic crisis in the country reclamation systems almost fully came out of operation, pumping stations hydrostructures were destroyed. Funds allocated for O&M are unsatisfactory for repair and rehabilitation that caused irrigated area reduction.

5. Storm runoff from cities and landfills also pollute surface waters. Landfills have not treatment facilities and observation wells. They are mostly located on river banks. Landfills in all cities are "burning points" and do not meet water protection requirements.

In accordance with Georgian legislation, water resources are property of state, which gives licenses for water use. Major consumers are power engineering and irrigated agriculture. As it was mentioned before, Georgia is rich in hydropower resources. There are about 100 large and small hydropower stations with designed capacity lObln.kwt.h or 20 % of economic potential.

2. Discussion

Climatic conditions variability dictates necessity of land reclamation. In Western Georgia with humid climate and intensive precipitation drainage is expedient. In Eastern Georgia with arid climate irrigation is needed.

Water quality assessment: The following categories of surface water bodies are established based on water use purposes:

- first category – water bodies used for drinking purposes;
- second category – water bodies used for recreation;
- third category – water bodies used for fish breeding.

For each category five classes of quality are established:

First class – very good quality (blue color of water). Pure oligotrophic water in natural conditions; insignificant anthropogenic pollution is allowed. Water is characterized by stable high concentration of oxygen close to full saturation. Low concentration of bioorganic elements and bacteria facilitates salmon breeding. Protective water potential is very high.

Second class – quality is good (green color). Insignificantly polluted mezotrophic water. Certain amount of organic matters from wastes after treatment. Water bodies are well saturated with oxygen all round year. Protective potential is well maintained. Inflows do not contain harmful matters.

Third class – water quality is satisfactory (yellow color). Temperate eutrophic water containing insignificant amount of organic matters and bioorganic elements. Sometimes lack of oxygen is possible. Protective potential is weak. Pollution with harmful matters and microbes. Harmful matters concentration varies from natural to toxic level.

Fourth class – water quality is unsatisfactory (orange color). Eutrophic water significantly polluted. Contains organic, bioorganic and harmful matters. Sometimes lack of oxygen is possible. Organic matters destruction and settling facilitate anaerobic processes and cause fish perishing. Pollution exceeds protective potential. Microbes do not allow use water body for recreation.

Harmful matters negatively impact fauna and flora. For fauna and flora harmful matters concentration varies from permanent to highly toxic level.

Fifth class – water quality is bad (red color). Very highly polluted hypertrophic water. Main problem is connected with oxygen regime, when lack of oxygen causes anaerobic processes. Reducents exceed producents. Water has not protective potential. Harmful matters concentration exceeds high toxicity level for fauna and flora.

The Rioni or Rion River is the main river of western Georgia (Adeishvili, Berdzenishvili, 2020). It originates in the Caucasus Mountains, in the region of Racha and flows west to the Black Sea, entering it north of the city of Poti (near ancient Phasis). The city of Kutaisi, once the ancient city of Colchis, lies on its banks. It drains the western Transcaucasus into the Black Sea while its sister, the Kura River, drains the eastern Transcaucasus into the Caspian Sea. Rioni is the most abundant river. Water pollution in the Rioni begins with the origins. From traditional polluting facilities should be noted Kvaisskoe, Tutiyskoe businesses, a lot of Oni and Ambrolauri businesses that poured on the raw water in the Rioni. And the most polluted river in the territory of Kutaisi (Adeishvili, Berdzenishvili, 2020).

Fig. 1. Georgia. River Rioni

The investigated region is situated in the western part of Georgia, in the Rioni River delta. Four municipalities share the Rioni River delta within the area of our interest: Khobi, Senaki, Lanchkhuti and Poti regions with port city Poti. This is the populated region with developed infrastructures. The south part of Rioni River floodplain towards the Black Sea is covered in Kolkheti marshes and Lake Paliastomi. They represent the most extensive wetland areas within the Black Sea region. Wetlands in Central Kolkheti have been designated as wetlands of international importance by the Ramsar Convention and represent a national park of the Georgia. The area of park is 28 940 ha (Jaoshvili, 2004). The total surface of our study area amounts to 350 km².

3. Results

The Rioni River is the principal river of western Georgia. It originates from the Caucasus Mountains, in the region of Racha and flows west to the Black Sea. The length of the river is 327 km, the area of the entire catchment amounts to 13 500 km². Fifty-one percent of the Rioni drainage area is situated in a mountain region. Upstream from Kutaisi, the river flows along a wild, narrow rift while downstream from Kutaisi it flows into extensive swampy lowland that abruptly changes the character of the river's flow to a meandering channel, forming numerous sand islands. The Kolkheti lowland is an intermountain depression with near flat geomorphology and is covered by marine and fluvial sediments (Maruashvili, 1971). It is tilted to the west where the altitude is less

than 10m above sea level and to the east the heights gradually increases up to 150 meters. The climate is determined by the Black Sea to the West and the amphitheatre of three big mountain ranges (the Great Caucasus, the Likhi and the Meskheti), in addition to the surrounding Kolkheti lowland (wetland) in the centre. Because of its geographic situation the Kolkheti lowland region represents unique climate grouping. It combines a high annual temperature of 14,10 C with extremes ranging from -150 C to +450 C. The annual amount of precipitation varies between 2,531 mm in the south and 1,458 mm in the north of Kolkheti lowland. 29 % of the precipitation falls in summer. Consequently, annual air humidity is high with values between 70 % and 83 % (Poti station).

Rioni River is the largest river of the Georgian Black Sea basin. An average annual water discharge of the river is 430 m^3/s with extremes ranging from 2480 to 3640 in the Rioni River delta. Rapid warming, intensive snow melt and/or high precipitations are the cause factors of raising the discharge in the Rioni River. Disastrous floods mainly caused by rapid warming and intensive snow melt or by dike break, result in extensive damage. For example, the population in Imereti was reduced by 30-35 % as a consequence of floods on the River Rioni in 1811–1812. In 1982 inundated area made up 130 km and had cost US $ 12 million (Bondyrev, Tsereteli, 2009).

Table 1. Analysis of river Rioni master data

Physical and chemical indicators of water	Rioni River until the entrance of Kutaisi	Rioni River in the middle of the city	Rioni River after leaving the city
The total Water vapidity	2.2	21.3	3.1
Transparency (cm)	2	1	3
Reaction (PH)	8.1	8	8.45
particles	282	187	134
Solids	145	115	145
Permanganate oxidation permanganate oxidation	4.13	1.04	3.4
Oxygen in the water	10.3	9.38	9.5
ammonium Nitrogen	1.17	1.09	0.35
Petroleum products	0	5	3.14
chlorides	Not detected	Not detected	0.35
Chromium	Not detected	Not detected	
Manganum	Not detected	Not detected	
Iron	0.5	0.4	0.5
The total number of bacteria	3000	11000	2350
Koli-index	18000	23000	23000
Koli-titer	0.06	0.04	0.04

4. Conclusion

Safe drinking water supply is major issue for Georgia. Presently, due to difficult economic situation, critical situation takes place in most water supply systems. Water quality control is weak and water quality sometimes does not meet standards. More dangerous situation occurs in sanitation and treatment of industrial and municipal wastes in cities and settlements. Treatment facilities mostly are out of operation and destroyed. Because of that, wastes are released to surface water bodies. This is one of the reasons for infectious illnesses growth, carcinogenic and mutant factors (Kereselidze, Trapaidze, 2012). As can be seen from the Table 1, the total number of bacteria, Rioni River until the entrance of Kutaisi 3000, Rioni River in the middle of the city 11000, Rioni River after leaving the city 2350. Rioni in Kutaisi is polluted by industrial enterprises.

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