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Variations in macrochemistry, nutrients and heavy metals during hydrological events in a small Norwegian stream

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This thesis is worth 60 study points

Abstract

This investigation has emphasized on transport of particles and nutrients during different hydrological events in a water course in Southern Norway, primarily draining agricultural areas. Two streams, Borjaevju and Prestevju, enter artificial made retention dam system (Dam A, B and C) before leaving the dam through the Evjudalen stream. Thus, a major goal was to investigate the retention potential of nutrients, primarily phosphorous (P), in the artificial made dam system. The chemistry in the two streams was very different, with much higher electrolytic conductivity (concentrations of ions) and nutrients in the Prestevju stream compared with the Borjaevju stream.

Anthropogenic influence like agriculture, settlement and sewage discharge may have large impacts on stream water chemistry including turbidity or TSS (Total suspended particles) and subsequent particle associated compounds as TP, heavy metals and organic micropollutants. TSS and turbidity were also strongly and positively correlated with TP in our study. Turbidity and TSS were also strongly positively correlated to water discharge, i.e. at highest during spring and autumn floods, but with significant chemical differences between the two seasonal flood episodes.

Highest concentration of nutrients especially, nitrogen and phosphorus, were observed during spring flood, likely as a result of fertilizing of agricultural land at that time of the year. Despite significant higher turbidity/TSS peak values during the autumn flood, the Total-P was lower than during the spring flood, indicating lower P-particle load during autumn.

Our calculations for retention of particles and particle associated nutrients in the artificial dams, showed retention of turbidity with subsequent retention of TN, TP, Tot-Fe at low to medium flow rates, i.e. up to ≈ 1000 L sec^{-1}measured in the Evjudalen stream located about 200 m downstream from dam area outlet.

Contents

Foreword

I owe my gratitude to my supervisors Espen Lydersen and Jan Heggenes who recommended me to conduct this project. Project field was conducted in Evjudalen catchment which consist Borjaevju, Prestevju and Evjudalen stream with three retention ponds (Dam A, B, and C).

I would like to thank co-ordinator and other members of Department of Nature, Health and Environment for support and encouragement. I am indebted to Synne Kleiven and Tom Aage Aarnes who manage their schedule for guiding me on laboratory test. To my teammate, Hilde, who collaborated with me on laboratory analysis.

Finally, I am grateful to my wife, family members and friends for their support and motivation throughout my study.

Bø, Telemark, (15/11/2020)

Nitish Dahal

Abbreviations

ANOVA – Analysis of Variance

BMP – Best Management Practices

Ca^{+2} -Calcium

Cl^{-} - Chlorine

Cu - Copper

CWs - Constructed Wetlands

Dis. N - Dissolved Nitrogen

Dis. P - Dissolved Phosphorus

Fe - Iron

HM - Heavy Metals

K^{+} - Potassium

Mg^{+2} - Magnesium

Mn – Manganese

N – Nitrogen

Na^{+} - Sodium

NO_3^{-} - Nitrate

Org-N – Organic Nitrogen¨

P – Phosphorus

Part-N – Particulate Nitrogen

Part-P – Particulate Phosphorus

SO_4^{-2} - Sulphate

TOC – Total Organic Carbon

TN – Total Nitrogen

TP – Total Phosphorus

TSS – Total Suspended Solids

Zn - Zinc

1 Introduction

Water is fundamental needs of human being; so, it is utmost necessity to maintain water quality. Water influences its neighbouring environment as well as catchment characteristics (Bowden, Konovalske, Allen, Curran, & Touslee, 2015). Hynes (1975) initially introduced terrestrial-aquatic relationship perception, in which stream acts as open system that is closely connected with its nearby landscapes. Geology, hydrology, flora, and climate of landscape near stream hinders aquatic ecosystem (J. Allan, 1995; J. D. Allan & Johnson, 1997; Johnson, Richards, Host, & Arthur, 1997; MI Stutter, Deeks, Low, & Billett, 2006). Chemistry of stream is associated to geology of watershed during low rainfall (Faure, 1997). River drains wastewater from factory, housing and physical structures, and agricultural fertilizers (Elliot & Ward, 1995). Runoff is major cause of non-point source pollution in stream; which transport variety of contaminant depending on catchment characteristics. For instance; nutrients and sediments are carried from agricultural areas and heavy metals, sodium, sulphate and rubber fragments from urban areas (Tong & Chen, 2002).

Water quality tends to be hindered from natural and artificial means, which is stimulated with temporal and spatial scale (Meybeck, Chapman, & Helmer, 1990); where, geological features and characteristics, temporal changes in water flow, depth of water and landscapes characteristics may be natural factors (Bartram & Ballance, 1996). Furthermore, land use as an anthropogenic factor causes non-point source and point source water pollution (Lenart-Boroń, Wolanin, Jelonkiewicz, Chmielewska-Błotnicka, & Żelazny, 2016). Thus, land use is a principal cause of variation of solid particles and transport of nutrient on water source (R. Bartley, Speirs, Ellis, & Waters, 2012).

Nutrient transportation is a natural phenomenon. Nutrients on soil are transported to water source either in dissolved or particulate form. Nutrients transportation get easily access to aquatic species which simultaneously improves the aquatic ecosystem. Artificial means such as cultivation, industrialization, farming, urbanization and recreation may be supplement cause for promoting nutrients transportation in water source (Jensen, Tiessen, Salvano, Kalischuk, & Flaten, 2011). The study conducted in Alberta by Lorenz, Depoe, & Phelan (2008), suggested that water quality is inversely proportional to agricultural intensity, and amount of N & P rises on flowing water. Water sources like streams, lakes and swamps can be eutrophicated due to additional N & P that promotes algal blooms and aquatic plants growth. The life cycle of algal blooms is responsible for anoxia in water sources, which directly hamper other aquatic species (Jensen et al., 2011). Eutrophication problems have driven people's interest on pollution of lakes, rivers and Baltic sea due to non-point source of Nitrogen and Phosphorus (Enell & Fejes, 1995; Larsson, 1985; Stålnacke, 1996). Phosphorus has shown main limiting nutrient in most water bodies(Foy, 2005). Many researchers have recommended that 20-80% of particulate phosphorus (PP) can be easily available to algae if it is organic (especially combined with clay particles) (Golterman, Bakels, & Jakobs-Mögelin, 1969; Hegemann, Johnson, & Keenan, 1983; Williams, Shear, & Thomas, 1980; Young & DePinto, 1982). Migration factors (runoff, erosion, and channeling) and other sources (soil, crop, and management) determines the amount of N loss in agricultural catchments (Blankenberg, Haarstad, & Søvik, 2008). Nitrogen application proportionally influence N-leaching (Simmelsgaard, 1998). Moreover, watershed characteristics have tremendous influence on average N loss (Vagstad et al., 2004). Large scale research found that agricultural land was responsible for 45% of total nitrogen loads on southern half of Sweden (Arheimer & Brandt, 1998). Measures to control heavy flow of nutrient from arable land have only 15% of net effect (Arheimer & Brandt, 2000).

Erosion process is accelerated on catchment with high proportion of agricultural coverage (Kondracki, 2000). It is also a prime source to conveyance organic and inorganic nutrients to water source (Krogstad & Løvstad, 1989). Biogeochemical process of nutrients on earth surface such as land, water, air and species influence nutrient concentration on water flow. The effect of rainfall, snowfall and sediment can be quickly noticed on small streams than bigger rivers (Duvert, Gratiot, Némery, Burgos, & Navratil, 2010; Jones, Horsburgh, Mesner, Ryel, & Stevens, 2012). In frozen regions, runoff is accelerated during snowmelt period and winter season when the land is freezing; which prohibit water to be absorbed (Nina Syversen, Øygarden, & Salbu, 2001).

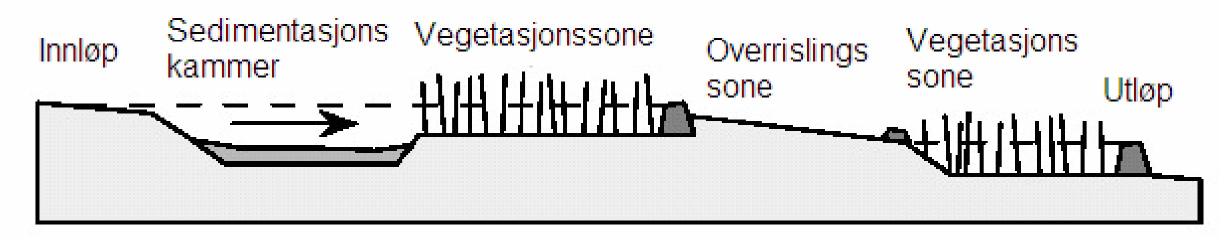


Figure 1-1 Structural functioning of dams to control nutrient transport (B. Braskerud, 2002)

Constructed ponds in different places have shown their capability to reserve huge quantity of headwater streams (Fairchild & Velinsky, 2006). Small ponds can spatially and temporally impact the stream system by changing the fish mobility in water system, enhancing aquatic environment for which prefers for habitat for diversity of flora and fauna, improving groundwater recharge and rising evaporation (Smith, Renwick, Bartley, & Buddemeier, 2002). Additionally, sedimentation of particle due to small ponds has been rising consideration (Verstraeten & Poesen, 2000). These ponds have ability to change the downstream water chemistry (Stanley & Doyle, 2003; Vörösmarty & Sahagian, 2000). Water flowing through small ponds tends to modify water chemistry by changing rate of central biogeochemical process like dissolved-particulate adsorption (e.g. PO_4^{3-}), biological uptake of liquefy nutrients (e.g. SiO2 or NH_4^+) and transformations (e.g. NO_3^- to N2(g)); which can be apparent on downstream (Humborg, Ittekkot, Cociasu, & Bodungen, 1997; Martin, Mulholland, Webster, & Valett, 2001; Newbold, 1987). A multi-pond system constructed to restraint farmland runoff was able to retain 87% of total phosphorus flowing through the pond network (Yin & Shan, 2001).

In Norway, stream has significant impact on dissecting larger agricultural land into smaller area (around 5 – 20 ha.) (B. Braskerud, 2001). Tremendous destruction of stream started since 1950s, to enlarge agricultural productivity. So, streams were blocked and gullies in fertile clayey soil were flattened. Moreover; other water sources like shallow pond and peat land were dried to create farmland(B. Braskerud, 2001). A study conducted in south-eastern Norway showed that streams and wetlands visible in 1790 were extinct from Rakkestad catchment by 1980 (Røsten, 1987). However, such trends of ruining water source were prohibited from 1989. Simultaneously, construction of sedimentation pond was emphasized to preserve the migrations of soil particles from catchment (B.

Braskerud, 2001). Larger area of pond creates favourable space for settling of clay particles (C.-N. Chen, 1975; Novotny & Chesters, 1981) and it was difficult to create big spacious pond on Norway due to small scale farmland(B. Braskerud, 2001). So, such ponds must be deeper to sediment particles in order to result similar effect of larger pond (C.-N. Chen, 1975). B. Braskerud (2001) mentioned planted aquatic species in such pond was able to control resuspension and storm erosion; which was named as constructed wetlands (CWs). Additionally, same research suggested that plant functioning in CWs help to promote sedimentation and diminish resuspension of particles. Best management practices (BMP) in agricultural land tends to reduce nutrients amount in downstream; due to its modification with CWs in first and second order enhances mechanism, like sedimentation, plant uptake and microbial N recycling. Nitrogen retention is proportionate with CW coverage (B. C. Braskerud, 2003). CWs in Norway are generally small (<0.1% of the catchment) because of rough landscape and small-scale agriculture. It is utmost significant to enhance N-retention where area of CWs cannot be enlarged (Blankenberg et al., 2008). Nutrient retention in wetland is consequence of specific factors such as hydraulic load (Arheimer & Wittgren, 2002; Koskiaho, 2006), as well as seasonality and nutrient load (Richardson, 1985). Constructed wetlands are initiated usually to interrupt the eroded soil particle and associated P from arable land. Sedimentation is major factor for upholding of particles and associated P in wetlands (R. H. Kadlec, and R.Knight, 1996). Lower amount of water flow and more retention time rise the sedimentation rate (Johnston, 1991). Minimum ratio of wetland area to catchment area in small wetland may increase hydraulic load which simultaneously decline the particle retention (Stephan, Hengl, & Schmid, 2005). In contrast, high amount of particle load in small stream may increase area-specific retention (B. C. Braskerud, 2003) . There is lack of proper idea on effectiveness of wetlands and buffer zones for P retention in area rich with clayey soil which transports excessive P to water bodies (Barbro Ulén & Snäll, 2007). P is mainly retained by sedimentation, but chemical sorption and floral uptake can also retain P (Reddy, Kadlec, Flaig, & Gale, 1999). A study conducted by B. Braskerud (2002) in Norwegian small wetlands with deep sedimentation ponds incorporated with shallow floral filters demonstrated efficient sedimentation of particles and TP (21-44% of TP load).

Watershed runoff is responsible for transport of particles and its associated nutrients. Higher amount of water flow results the rise of sediments in stream which tremendously changes water quality. So, these particles associated nutrient could be problem of eutrophication in downstream. The proper management practice for controlling nutrient is important concern on these days. Most of researcher have focused on constructed wetlands as effect measure for interrupting particles on Norwegian stream water. So, this study has emphasized to comprehend the nutrient concentration especially total nitrogen and total phosphorus during flooding events. Additionally, this investigation will demonstrate role of retention ponds, one of the conservative measures, for retaining particles.

Objectives

The main goal of this thesis is to study water chemical variations during flood episodes, from low flow to high flow, and the retention effects of particles and particle associated compounds in the artificial made retention dams in Evjudalen, Midt-Telemark municipality, Norway. The objectives of this study are mentioned below:

i) Determine water quality changes on Borjaevju, Prestevju and Evjudalen stream during hydrological events
ii) Demonstrate influence of catchment on stream water chemistry
iii) Comprehend the effects of dams to retain the nutrient

2 Literature Review

2.1 Land Use

Intimate association has been found between catchment characteristics and water quality and quantity (Gburek & Folmar, 1999). Agricultural catchment is responsible for high flow of nutrient concentration in stream (Lenat & Crawford, 1994). Additionally, a study conducted by Fisher et al. (2000) in Upper Oconee Watershed suggested that poultry production catchments can produce huge concentration of nitrogen, phosphorus and *Fecal coliform* bacteria. Due to the land use pattern; there is variation on water quality parameters which is demonstrated on a study in western North Carolina (Bolstad & Swank, 1997). Thus, catchment characteristics and land use changes are significant factor for determining water circulation and water flow velocity (Mander, Kull, Tamm, Kuusemets, & Karjus, 1998). Additionally, land use pattern and its changes can have proportional impact on changes on water quality (Changnon & Demissie, 1996).

Land use can alter the transportation of particulates and nutrient concentration to water sources (R. S. Bartley, W., 2010). Many studies demonstrated that variation on water quality parameters due to natural cause or by land use can be clearly revealed from information gathered from water quality constituents and land situation (R. S. Bartley, W., 2010). The study of fine particles transportation like clay is utmost because turbidity and phosphorus (Sharpley, 1980), heavy metals (Kabata-Pendias, 2004) and pesticides (Leonard, 1990)are closely interlinked with them. Human influence and natural cause both accelerate non-point source pollution; for instance, contaminants from catchments are transported in water bodies due to precipitation and snow melting (Lenart-Boroń, Wolanin, Jelonkiewicz, Chmielewska-Błotnicka, et al., 2016). However; outflow from infrastructural waste water treatments are major components for point source pollution (Nnane, Ebdon, & Taylor, 2011).

2.2 Phosphorus

Major limiting nutrient for algal growth in water bodies is phosphorus (Berge, Fjeld, Hindar, & Kaste, 1997).It has been identified that particulate phosphorous is major constituents that is carried by runoff from arable land (Koskiaho, Ekholm, Räty, Riihimäki, & Puustinen, 2003; Barbro Ulén, 2004; Uusitalo, Turtola, Puustinen, Paasonen-Kivekäs, & Uusi-Kämppä, 2003; Uusitalo, Yli-Halla, & Turtola, 2000). A research in Finland showed that 73-94% of particulates were phosphorus in water flow from agricultural catchment (Uusitalo et al., 2003). A sediment study suggested that bioavailable phosphorus and clay content are strongly correlated (Maynard, O'Geen, & Dahlgren, 2009). Additionally, Kronvang (1992) suggested that clayey soil can hold phosphorus easily. Generally, particulate phosphorus contains agricultural soil constituents and organic matter, eroded due to surface runoff or drainage system during irrigation, rainfall, and snow-melting. Phosphorus found in clay particles is 12 times higher than sand particles associated P (Pacini & Gächter, 1999).

Total phosphorus loading in runoff is fractionated with 15, 20,17 and 41% agricultural phosphorus in Denmark, Norway, Sweden and Finland respectively (Kronvang & Svendsen, 1991). In agricultural land of Norway, high concentration of phosphorus (90%) flow is estimated on winter (N Syversen, 2002). Particulate Phosphorus percentage is high on total phosphorus transported by surface runoff because water flow carries eroded particles. On other hand; snow melting is less erosive, so Dissolved Phosphorus concentration is higher than Particulate Phosphorus in total Phosphorus (Jensen et al., 2011). Karlsson (2005) suggested that maximum percentage of concentration of dissolved P (88%) was found in wastewater discharge. Most of the studies enlightens strong correlation between phosphorus concentration on snow melted runoff and phosphorus amount on surface soil (Little, Nolan, Casson, & Olson, 2007; Salvano, Flaten, Rousseau, & Quilbe, 2009). Area with higher concentration of phosphorus represents strong relationship between phosphorus and turbidity (Villa, Fölster, & Kyllmar, 2019). Phosphorus is main responsible nutrient for eutrophication in Northern Great Plains which is diagnosed by algal blooms. Northern Great Plains have productive land and aquatic ecosystem along with high Phosphorus amount (Barica & Allan, 1988).

2.3 Nitrogen

Nitrogen as a vital element; is easily available on earth surface on various chemical forms. Anthropogenic factors are responsible to accelerate the concentration of naturally occurring nitrogen parameters like Nitrate and others (Dubrovsky et al., 2010). Nitrogen parameters available in soil and water are influenced by temperature, oxygen levels and bio-chemical status (Wall, 2013). Nitrate and organic nitrogen are main form of Nitrogen that is readily available on surface water. Nitrate concentration elevates organic nitrogen when stream relates to agricultural catchment and organic nitrogen is noticed higher than nitrate on natural conditions like forest and grasslands (Wall, 2013). Nitrogen loss from agricultural watershed is consequence of excessive utilization of fertilizer in farmland, and leads to aquatic ecosystem imbalance (Povilaitis, Šileika, Deelstra, Gaigalis, & Baigys, 2014; Povilaitis, Stålnacke, & Vassiljev, 2012; Stoate et al., 2009). Additionally, Nitrogen pollution in stream is the result of livestock dung disposal and excessive Nitrogen in arable land (Woli, Nagumo, & Hatano, 2002).

Nitrogen concentration is highly dependent on agricultural practice and its area. For instance; a study conducted by X. Chen & Bechmann (2019) in Skuterud and Naurstad catchment had shown that nitrogen concentration in Skuterud catchment was five times higher than Naurstad catchment because Skuterud catchment (61%, 273.9 hm^2) have five times bigger agricultural area than Naurstad catchment (35%, 51.1 hm^2). Additionally, Area with soil tillage and cereal production demonstrated high nitrogen loss than grassland (García-Díaz et al., 2017; Hansen & Djurhuus, 1997).

2.4 Turbidity and Total Suspended Solids

Turbidity is a measure of light that is affected by solid particles in water (Villa et al., 2019). Most of the research have been using turbidity as substituent estimator of suspended solid amount (Villa et al., 2019). Solid particles size and composition along with colour are confounding factor for turbidity and suspended sediment relationship (Bright, Mager, & Horton, 2018; Muff, Signer, & Fieberg, 2020). In most of the stream, turbidity can act as decent predictor for developing simple association with total phosphorus and suspended sediments (Villa et al., 2019). Turbidity can be used as substituent of TP relying, on fact that higher proportion of particulate phosphorus is present in transported TP (Rügner, Schwientek, Beckingham, Kuch, & Grathwohl, 2013; Settle, Goonetilleke, & Ayoko, 2007; Stubblefield, Reuter, Dahlgren, & Goldman, 2007). The concentration total suspended solid is less in summer in comparison to spring and summer (B. Braskerud, Lundekvam, & Krogstad, 2000; B. C. Braskerud, 2003).

2.5 Heavy Metals

One of the biggest problem of world is heavy metal pollution (Sekabira, Origa, Basamba, Mutumba, & Kakudidi, 2010). Weathering of rocks as a terrigenous source enhances geochemical recycling of heavy metal which compels at least low presence of heavy metals on water source(Muwanga, 1997; Zvinowanda, Okonkwo, Shabalala, & Agyei, 2009). These trace element may take part in absorption, co-precipitation and complex formation due to being stagnant within sediments (Mohiuddin, Zakir, Otomo, Sharmin, & Shikazono, 2010; Okafor & Opuene, 2007). In some circumstances they may be available as oxides or hydroxides of Fe and Mn due to co-adsorption with other elements or may be in particulate form in stream (Awofolu, Mbolekwa, Mtshemla, & Fatoki, 2005; Mwiganga & Kansiime, 2005). Heavy metals may be due to natural and anthropogenic source. Industrial wastewater flow, sewage wastewater, fuel combustion and atmospheric deposition may be counted as major artificial sources to drain heavy metals in water sources (Campbell, 2003; El Diwani & El Rafie, 2008; Idrees, 2009; Linnik & Zubenko, 2000; Lwanga, Kansiime, Denny, & Scullion, 2003).

2.6 Hydrological Events and Retention in Dams

Flooding is one of the most destructive natural phenomena that hampers socio-economic aspects of human. Flooding is responsible for destroying the animal’s habitat, loss of agricultural productivity, depletion of water quality and spread of disease. Increasing amount of water on water bodies leads flooding which ultimately result water pollution and life hazard (Ching, Lee, Toriman, Abdullah, & Yatim, 2015). Climate change can responsible for rise on flow velocity and hydrological events which simultaneously accelerates transport of nitrogen and phosphorus (McCullough et al., 2012). Moreover, lot of studies explains that increment of agricultural outflow channels and low conservative structure; like surface depression and wetland, can also accelerate the flow velocity and volume of water. A study conducted in southeast Norway mention the strong relationship between water flow and erosion and farming practice ploughing and tillage also accelerate soil erosion (B. Braskerud et al., 2000).

Figure 2-1 Overview of waterflow in stream through constructed dams

Major impact of large dams can be analysed from water flow variation, alteration of water quality, and modified sedimentation process, which hampers aquatic species (Hirji, Johnson, & Chauta, 2002; Mantel, Hughes, & Muller, 2010; Petts, 1984; Pringle, Freeman, & Freeman, 2000). Worldwide, larger dams' effects 59% of world biggest river by dissection of river and flow control (Nilsson, Reidy, Dynesius, & Revenga, 2005). Check dams are soil conservation measure that controls velocity of flowing water, minimizes soil loss and preserve nutrient rich sediments (Li et al., 2017). Likewise, small dams enhance sedimentation process that change habitat structure (Stanley, Luebke, Doyle, & Marshall, 2002). Regional and Global survey have suggested that river system may be distinctly influenced by small dams due to their numerous presence and surface occupied (Mantel et al., 2010; Rosenberg, McCully, & Pringle, 2000). Small dams are useful structure that serves human civilization; such as animal husbandry, agricultural production, fishery, silt trapping, and aesthetic value (Cecchi, 1998; Keller, Sakthivadivel,

& Seckler, 2000; A Senzanje & Chimbari, 2002; Sugunan, 1997). Aquatic as well as terrestrial ecosystem is improved by dammed water in reservoirs which ultimately support well-being of flora and fauna (Aidan Senzanje, Boelee, & Rusere, 2008). Water flow and particulates collides on small dams and modifies the nutrient migration through whole system (Oeurng, Sauvage, & Sánchez-Pérez, 2010). Sedimentation of nutrients on dam reservoirs blocks the nutrients aggregated with particulates from watershed. Due to such process nutrient concentration reduces along the water sources which proportional minimizes eutrophic condition on downstream (Liu, McLean, Long, Steinman, & Stevenson, 2018). Factors that hinders minor dams are variation on flow of its tributary stream and considerable use of water for different purpose. There is less retention time on small dams, so; they have probability to affect sediment features and its relations with water strata. The contact time among sediments and water regulates retention of nutrient. So, interaction of sediment and water is influenced by various factors such as; discharge, water height, transient storage, and physiography (Alexander, Smith, & Schwarz, 2000; Valett, Morrice, Dahm, & Campana, 1996). Additionally, channel structure can modify residence time which instantly impact on nutrient sedimentation (Gücker & Boëchat, 2004).

3 Methods

3.1 Study Sites

This research study was conducted in 3 small streams located in Bø,Telemark named as 1) Borjaevju, 2) Prestevju and 3) evjudalen. Bø is a circular valley with cold climatic region. Lake Seljord lies on NW and Lake Norsjø lies in SE of Bø. Borjaevju and Prestevju are upstreams and Evjudalen stream as downstream. Additionally, dam A, dam B and dam C on streams were studied to identify the role of constructed ponds in retention of particles and nutrients.

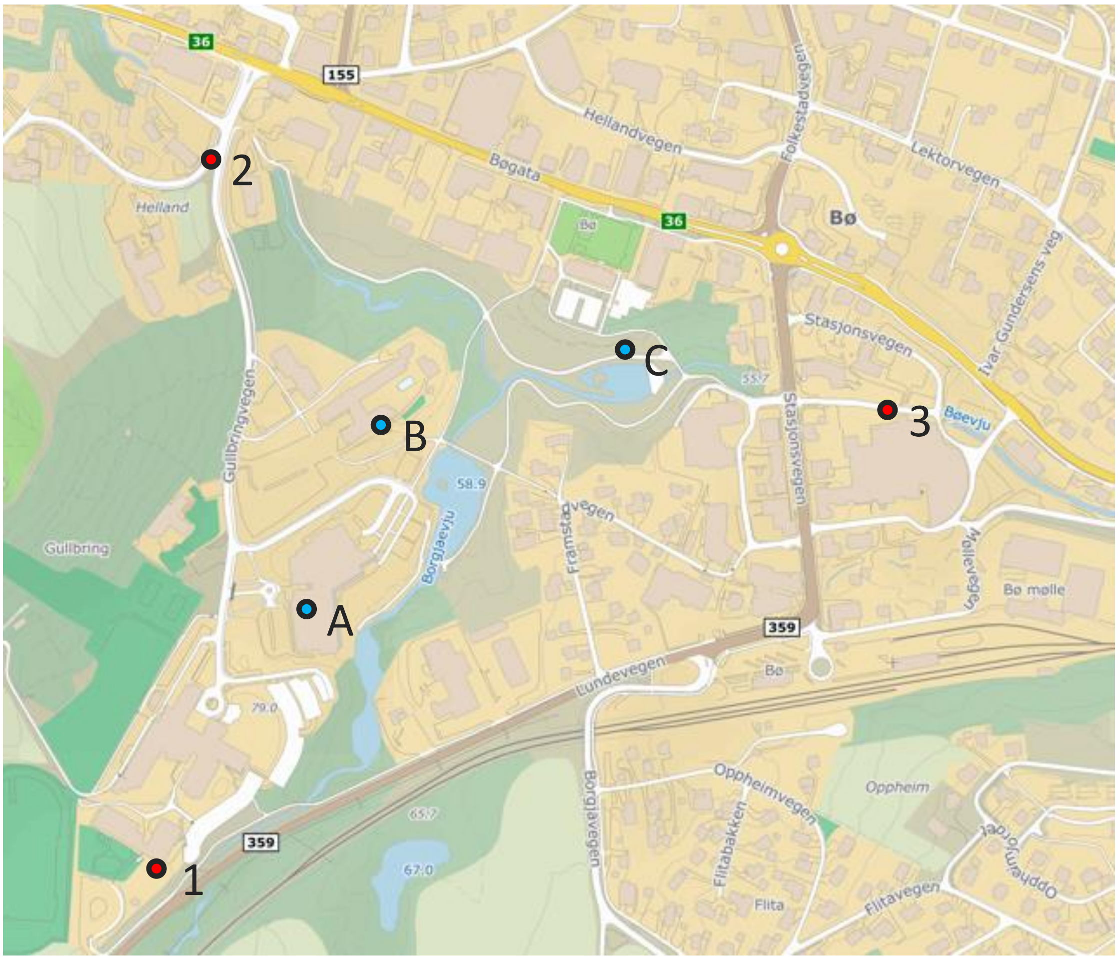


Figure 3-1 Study Area where st.1,2,3 represents Borjaevju,Prestevju & Evjudalen repectively and A,B, & C are constructed dams

The catchment characteristics varies on study area, which can be elaborated in table below:

Table 1-1 Catchment characteristics of Borjaevju, Prestevju and Evjudalen

Parameter	Unit	Borjaveju	Prestevju	Evjudalen
Area	km^2	10.92	5.29	18.6
Discharge	mm yr^{-1}	275.48	274.98	273.68
min hight	m a.s.l	73	65	58
max high	m a.s.l	373	398	398
Agriculture	%	21.31	32.68	24.96
Bog/Marsh	%	0.21	0	0.12
Urban	%	1.76	2.78	6.53
Summer temp[1]	°C	12.06	12.22	12.16
Winter temp[2]	°C	-1.37	-1.27	-1.31
Summer precipitation	mm	425.21	443.85	429.32

[1]May-September

[2]October-April

3.2 Data Collection

3.2.1 Sampling

Water samples were collected from May to October focusing on hydrological events. Simple random sample was used to identify the sample sites. Two upstream Station 1 & Station 2 and downstream Station 3 along with its dam A, B and C respectively were identified depending on nature of water catchment and stream flow. Before collecting sample, wooden ruler was marked to analyze the water height. Then, they were fixed before conducting data collection. Temperature and water height were recorded before sample collection. Salt dilution method was applied to estimate the discharge of stream. Salt dilution method is applicable on stream with undefined geometric cross section of stream, in highland waterflow where current meter cannot determine flow rate (Pitty, 1966; Sappa, Ferranti, & Pecchia, 2015). The function of time with injected solution conductivity help to determine water flow (Sappa et al., 2015). Two bottles of 0.5L water samples were collected from downstream i.e. station 3 then dam C, B and A following station 1 and 2. In salt method, saltwater (i.e. adding 1 kg of salt in 5 L of water) was poured on three stations. Conductivity was recorded at downstream around 10 meters distance depending on water velocity. In this research, injected conductivity was measured at each 5 seconds and their product (time*injected conductivity) gives electric conductivity of point. Total conductivity was calculated by formula:

$$C_t = \sum \left[\left(\frac{C_i + C_s}{2} - C_i \right) * (T_s - T_i) \right]$$

Where,

C_t= total Conductivity

C_i= initial conductivity of solution

C_s= second conductivity of solution

T_s= second measurement of time

T_i= intial measurement of time

After calculating total conductivity, discharge can be measured by following formula:

$$Q = \frac{M * 0.219}{t * C_t}$$

Where,

Q = discharge of stream

M = weight of salt used for solution

t = temperature

C_t= total Conductivity

Salt dilution method was adopted five times on each stream during sampling period and help to find out relationship between water flow and water level.

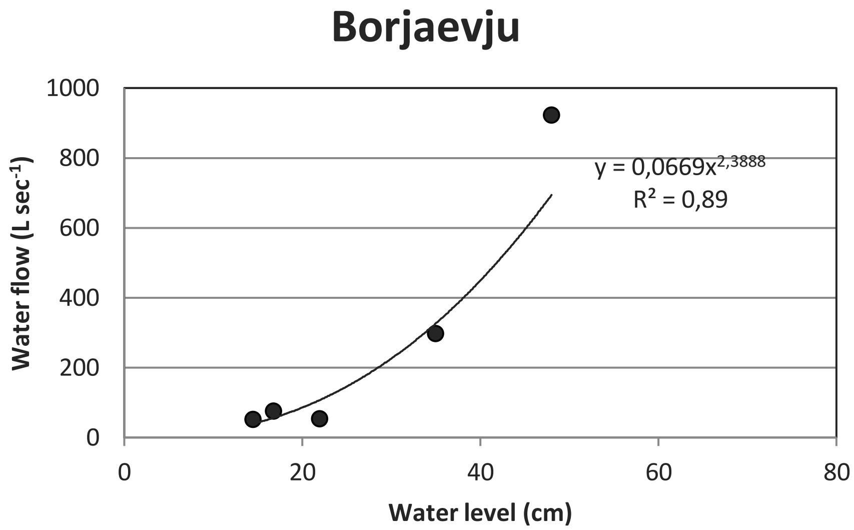


Figure 3-2 Relationship of water level and water flow in Borjaevju

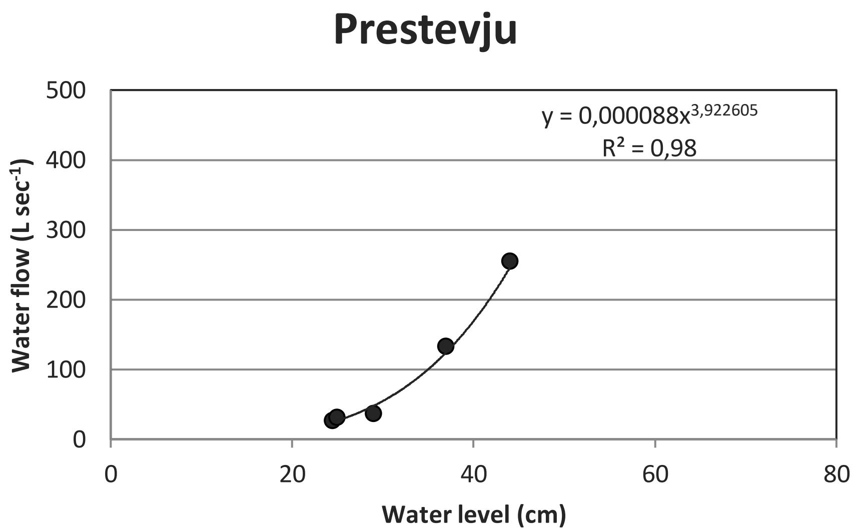


Figure 3-3 Relationship of water level and water flow in Prestevju

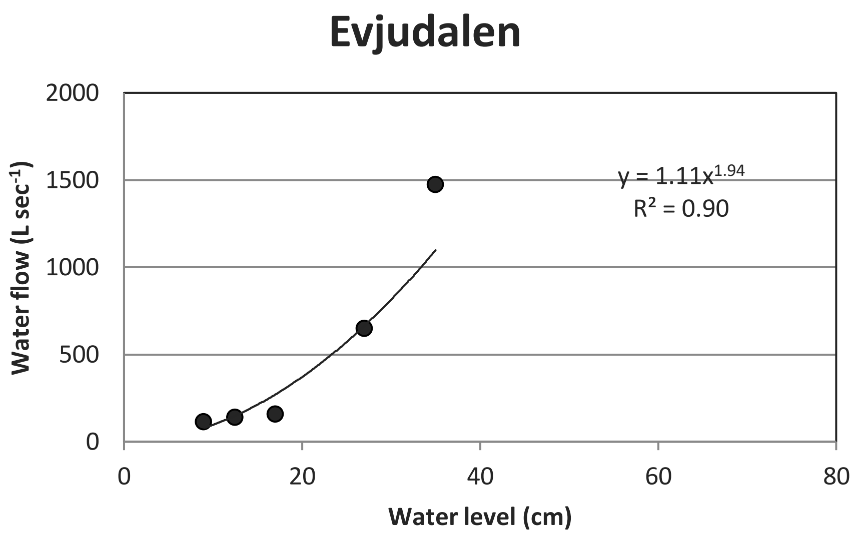


Figure 3-4 Relationship of water level and water flow in Evjudalen

According to above given figure, all streams demonstrate close association between water level and water flow. R-squared value (R^2=0.98) is higher in Prestevju stream which clearly illustrates that exponential trendline fit for best prediction of dependent variable. So, this regression equation (y = 0,000088$x^{3,922605)}$ is best equation for calculating water flow in Prestevju.

Figure 3-5 Water temperature on three streams

The highest temperature (19°C) was recorded during last of July in Evjudalen stream (Figure No.3-5). During autumn, temperature of water on all streams show tremendous decline of water temperature which continues till the end of the year. Temperature of Borjaevju, Prestevju and Evjudalen ranges similar during October and November than other months.

3.2.2 Laboratory Analysis

Samples were stored in freezer before conducting lab analyses. Laboratory task was carried out in Chemistry lab of University of Southeast Norway. Both physical and chemical parameter were analyzed. Phosphorous, Nitrogen, Turbidity, Conductivity, pH, and Total Suspended Solid as well as heavy metals like Manganese, Iron, Zinc and Copper were focused on analysis. Moreover, Calcium, Magnesium, Sodium, Potassium, Sulphate Chlorine and Nitrate were analyzed. Samples were kept on room temperature before conducting lab analysis. Laboratory analysis was conducted on two phases. There were 60 bottles of samples stored in cooler before analysis. Metabolism of organism gets minimized due to samples stored in freezer below 4°C (Shuhaimi-Othman, Lim, & Mushrifah, 2007). Samples of each heavy metals and Nitrogen & Phosphorous were analyzed on separate bottles. Initially, 100 ml of bottles were marked distinctly as red colour for heavy metals and blue one for Phosphorous & Nitrogen. Additionally, these bottles were differentiated to mark each total and filtrate samples of heavy metals and N & P which were further differentiated into a & b sub-samples (i.e. T(a), T(b), F(a) & F(b)). Thus, there were 60 samples of each N, P & HMs which were analyzed for total and filtrate (i.e. 30 total and 30 filtrate).100 ml of total samples were collected directly from 0.5 l bottles. Then, filtration method adopted to receive 100ml of filtrate samples. The weight of 60 filter papers were measured before filtrating samples. Thus, total (T) and filtrate (F) samples of 100 ml were assembled for HM and N & P. Filters were handled carefully and dried on oven for 24 hours.

1 ml of concentrated HNO_3 was added to each heavy metal samples, while 1 ml 4M H_2SO_4 was added to each sample before analyzed on total nitrogen (TN) and total phosphorus (TP). Each nitrogen samples were, both total (T) and filtered (f) were divided in 2 sub-samples named as Ta and Tb, Fa and Fb. Each sample were 10ml. Likewise, TP was evaluated after addition of potassium peroxodisulfate (B. Braskerud, 2002). These all plastic bottles were kept on machine for heating for one day. Then, nitrogen sub-samples were analyzed. Nitrogen parameters were on standard NS 4743 with Certoclav-Tisch-Autoclav, FIAlyzer 1000 and AIM3200 Autosampler. Phosphorous analysis was conducted as similar process of Nitrogen. Average of these subsamples give the actual amount of nitrogen and phosphorous present in samples. Heavy metals like Manganese, Iron, Zinc and Copper were analysed by atomic absorption spectrometry on a Perkin Elmer HGA 900 instrument (Graphite furnace) according to NS-4773 (1994). Major cations (Ca^{+2}, Mg^{+2},

Na^+, K^+) and anions (SO_4^{-2}, Cl^-,NO_3^-) were analyzed by ionic chromatography instrument type Dionex ICS-1000, RFIC according to standard methods (Table No.1). Also, turbidity, pH and conductivity were measured according to analytical standard methods. Total suspended solids were calculated by subtracting weight of filter paper before filtration from weight of filter paper after heating. Physical and chemical analysis of water sample were carried out with following given instrument and standard:

Table 2-1 Analytical equipment and standard for physical and chemical parameters

Parameter	Equipment/Machine	Standard
pH	Mettler Toledo SevenCompact S210	NS 4720
Conductivity	WTW Cond 3110 TetraCon 325	NS-ISO 7888
Alkalinity	Mettler Toledo G20 Compact Titrator and Mettler Toledo DG 115-SC electrode	NS 4754
Turbidity	Turbiquant 1100 IR	NS-EN ISO 7027-1
Ca^{2+}, Mg^{2+}, Na^+, K^+, NH_4^+	Dionex ICS-1100 Ion Chromatography System	NS-EN ISO 14911
SO_4^{2-}, Cl^-, NO_3^-	Dionex ICS-1100 Ion Chromatography System	NS-EN ISO 10304-1
TN	Certoclav-Tisch-Autoclav, FIAlyzer 1000 and AIM3200 Autosampler	NS 4743
TP	Certoclav-Tisch-Autoclav and Perkin Elmer Lambda 25 UV/VIS Spectrophotometer	NS 1189
True colour	Perkin Elmer Lambda 25 UV/VIS Spectrofotometer	NS-EN ISO 7887:2011C
Heavy Metals	Perkin Elmer HGA 900	NS-4773 (1994)

3.2.3 Statistical Analysis

Statistical software Minitab18 performed One-Way ANOVA for statistical analysis of water parameters. Turkey- Kramer multiple comparison was also conducted in order to identify statistically significant difference on study sites. Residual analysis supported to demonstrate normality and homogeneity of variance. Association of physical and chemical parameters were demonstrated by regression analysis. In addition, retention on dams were calculated by following formulas:

Firstly, Mass transport (mg s^{-1}) from the two catchments Borjaevju and Prestevju were calculated as follows:

$$C_{1+2} = \frac{(C_1 * Q_1) + (C_1 * Q_1)}{(Q_1 + Q_2)}$$

Where,
MT= Mass Transportation
C_1 = Concentration on station 1
C_2 = Concentration on station 2
Q_1 = Discharge on station 1
Q_2 = Discharge on station 2

Then, potential retention (R) of particles and nutrients in the dams were calculated as;

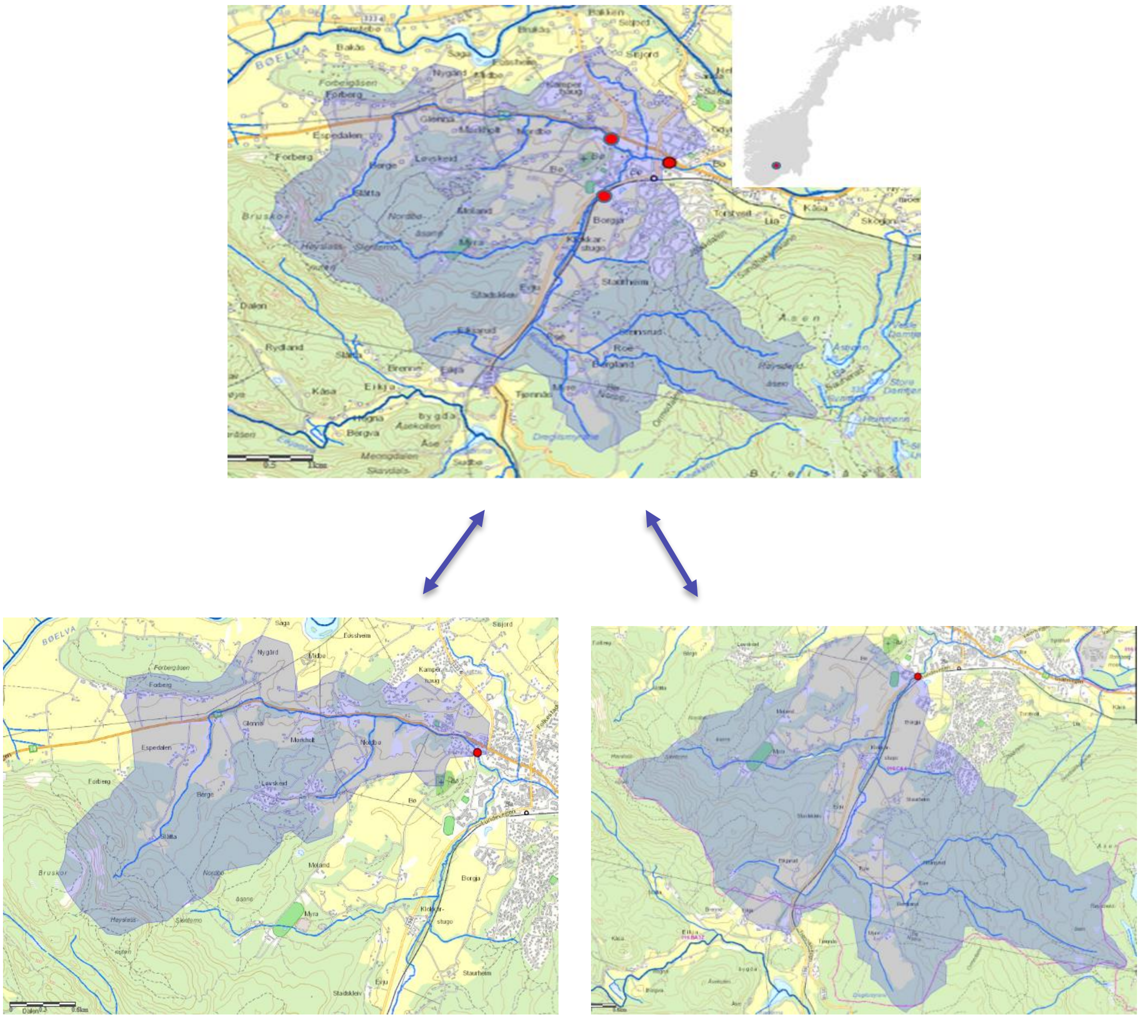
$$R = (C_{1+2} - C_3)$$

Where,

C_{1+2} = Volume weighted concentration average
MT_3 = Mass transport at Station 3, i.e. C_3/Q_3

4 Results

Bø is a hilly area dominated by agricultural field and urban area. Winter is too cold so cultivation is done from spring to autumn. Prestevju is highly influenced by both agricultural production and urban area. The soil type of the study sites is marine deposits basically clayey. Borjaevju and Prestevju are perennial stream in Bø which flows down to Evjudalen that drains into River Bøelva with outlet in Lake Norsjø.



Prestevju Borjaevju

Figure 4-1 Overview of Catchment area of Evjudalen along with tributaries Borjaevju and Prestevju (Source: https://nevina.nve.no/)

4.1 Water Chemistry During Hydrological Events

There was a variation in stream water quality on different flooding events. Comparatively, Evjudalen represented higher discharge concentration during sampling period. Regarding seasonal variation, there was greater amount of water flow during autumn flood (Table 3-1). The concentration of conductivity was highest from Prestevju stream during autumn flood. Likewise; Prestevju represented highest flow of ions concentration.

Table 3-1 Monthly mean concentration of parameters on sampling sites

Parameters	Month/Station	May	Jun	Sep	Oct	Grand Total
	Borjaevju	325	111	60	963	513
	Prestevju	89	45	34	205	122
Discharge(L/sec)	Evjudalen	577	271	127	1471	833
	Borjaevju	57.4	61.9	71.0	49.7	56.1
	Prestevju	133.5	155.1	187.8	104.3	128.9
Conductivity (mS/cm)	Evjudalen	99.5	103.5	126.8	67.5	89.8
	Borjaevju	7	7	7	7	7
	Prestevju	7	8	7	7	7
pH	Evjudalen	7	7	7	7	7
	Borjaevju	19	7	7	60	33
	Prestevju	54	10	5	56	46
Turbidity(NTU)	Evjudalen	56	8	6	36	38
	Borjaevju	6	1	4	48	22
	Prestevju	13	7	7	41	23
TSS(mg/L)	Evjudalen	10	3	4	24	14
	Borjaevju	101	116	88	124	110
	Prestevju	68	60	40	87	72
Colour(mgPt/L)	Evjudalen	81	91	64	111	92
	Borjaevju	78	28	24	60	61
	Prestevju	92	35	18	75	72
Tot-P(µg/L)	Evjudalen	71	44	17	50	55
	Borjaevju	26	26	13	39	30
	Prestevju	35	58	12	65	47
Dissolved P(µg/L)	Evjudalen	38	43	11	43	38
	Borjaevju	52	2	11	21	30
	Prestevju	58	-23	6	10	26
Part. P(µg/L)	Evjudalen	33	1	6	7	17
	Borjaevju	3774	2504	1234	1755	2585
	Prestevju	6134	6076	3046	3227	4657
Tot-N(µg/L)	Evjudalen	4744	4006	1800	2250	3378
	Borjaevju	1130	684	77	560	752
	Prestevju	2213	2697	686	577	1454
Org-N(µg/L)	Evjudalen	1546	1363	210	666	1042
	Borjaevju	2644	1820	1157	1195	1833
	Prestevju	3921	3379	2359	2651	3203
NO_3^-(µg/L)	Evjudalen	3198	2643	1590	1584	2336
	Borjaevju	2953	1745	1223	1488	2073
	Prestevju	3918	3163	2692	2893	3310
Dissolved N(µg/L)	Evjudalen	3196	2503	1750	1927	2474
	Borjaevju	52	2	11	21	30
	Prestevju	58	-23	6	10	26
Part. N (µg/L)	Evjudalen	33	1	6	7	17
	Borjaevju	215	227	678	841	513
	Prestevju	231	223	381	700	433
Fe(µg/L)	Evjudalen	215	245	545	649	425
	Borjaevju	21	20	22	16	19
	Prestevju	37	39	50	29	35
Ca^{+2} (µS/cm)	Evjudalen	29	30	36	22	27
	Borjaevju	6	7	8	5	6
	Prestevju	28	27	28	12	21
Na^+(µS/cm)	Evjudalen	15	14	16	7	12
	Borjaevju	9	9	10	7	8
	Prestevju	17	17	23	14	16
Mg^{+2}(µS/cm)	Evjudalen	13	14	17	10	12
	Borjaevju	2	2	7	6	4
	Prestevju	5	4	11	8	7
K^+(µS/cm)	Evjudalen	3	3	9	6	5
	Borjaevju	6	7	6	5	6
	Prestevju	8	10	10	7	8
SO_4^{-2}(µS/cm)	Evjudalen	8	9	8	6	7
	Borjaevju	8	8	10	7	8
	Prestevju	39	37	34	15	29
Cl^-(µS/cm)	Evjudalen	19	17	20	10	15

The concentration of particles in stream was affected by surface runoff in this investigation. As; the discharge concentration rised, the amount of particles increased simultaneously.

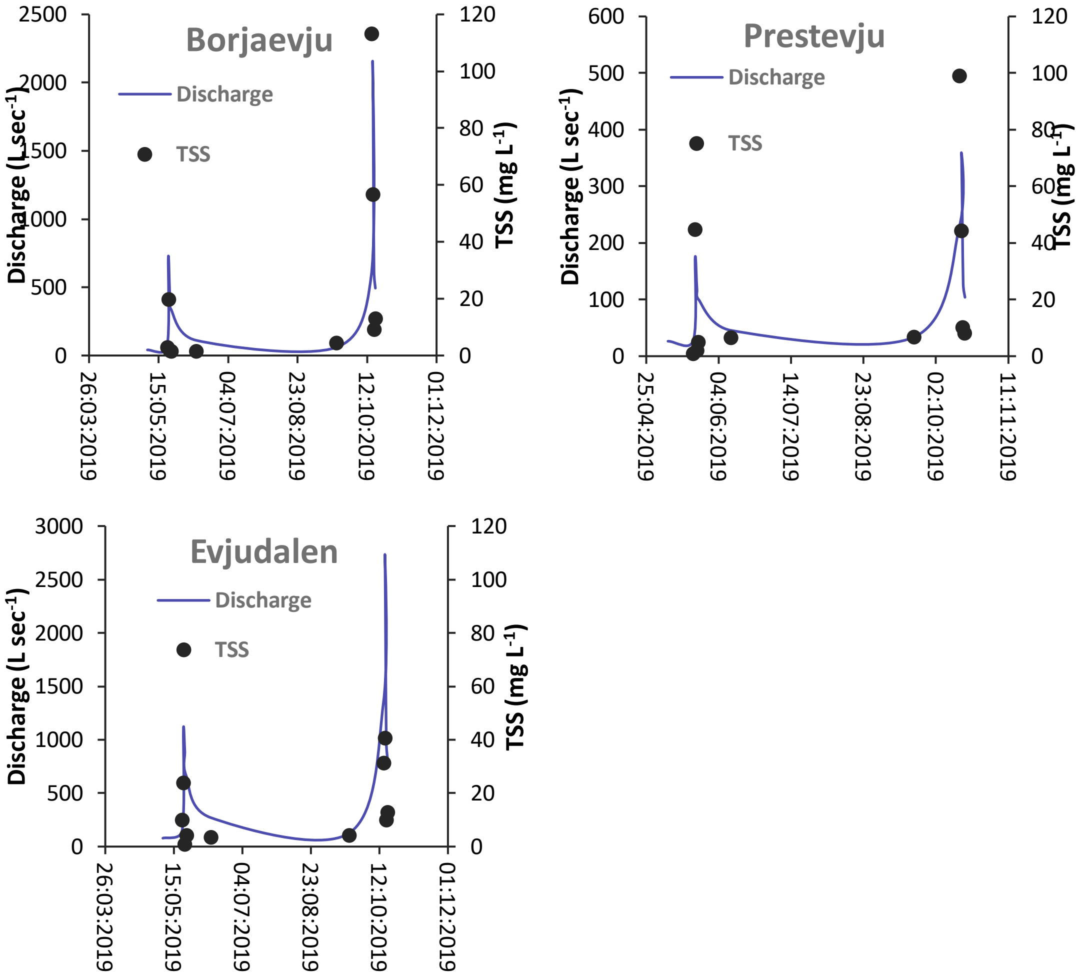


Figure 4-2 Distribution of TSS and discharge throughout the sampling periods in Borjaevju, Prestevju and Evjudalen streams.

Figure 4-2 shows distribution of water flow and discharge during sampling periods. In Borjaevju, higher amount of water flow was observed in October (above 2000 L/sec). Following this, the amount of TSS in Borjaevju increased upto 120 mgL^{-1}. There was low concentration of TSS during low amount of water flow and vice versa. Moreover, outlier was observed in October due to high flux of water. Like Borjaevju; the discharge concentration in Prestevju increased drastically after August which transported high amount of TSS above 100 mgL^{-1} in Prestevju. Outlier observed in Prestevju during autumn flood represents the function of excessive water flow that cause tremendous wash out of soil particles from catchment. In Evjudalen stream, there was maximum amount water flow but TSS concentration does not exceed 50 mgL^{-1}. However, the amount of TSS was greater than base flow. Thus, two hydrological events (spring and autumn flood) were responsible to accelerate TSS concentration on stream.

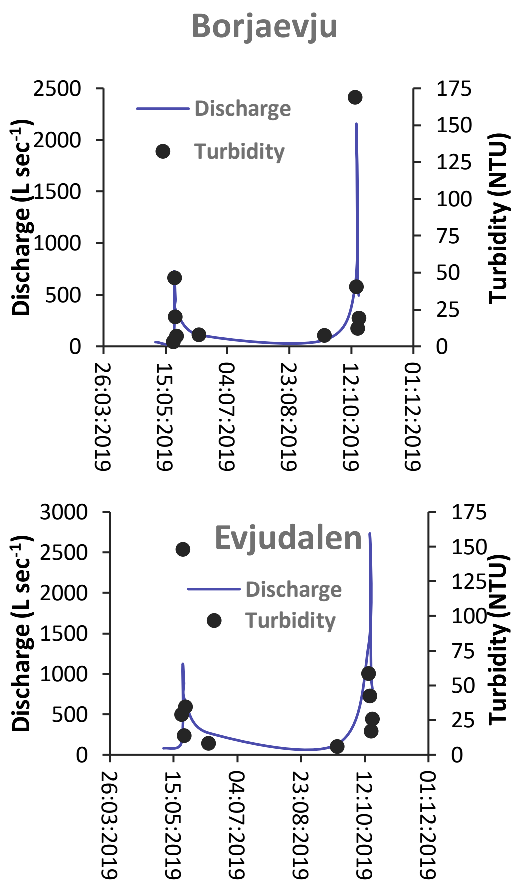


Figure 4-3 Distribution of turbidity and discharge throughout the sampling periods in Borjaevju, Prestevju and Evjudalen streams.

Figure 4-3 shows distribution of turbidity and discharge during inventory periods. In Borjaevju, the amount of turbidity in October increased upto 175 NTU and highest amount of discharge was measured above 2000 $Lsec^{-1}$. Concentration of turbidity was low in Borjaevju during low amount of water flow and vice versa. Additionally, excessive waterflow increase transportation of particles which can be observed as outlier in October. Like Borjaevju; the discharge concentration in Prestevju increased after August which transported high amount of turbidity (130 NTU) in Prestevju. Outlier observed in Prestevju during autumn flood also represents the function of excessive water for particle transportation. In Evjudalen stream, there was maximum amount water flow but TSS concentration does not exceed 60 NTU. However, the amount of TSS was higher than low flow. Thus, two flooding events (spring and autumn flood) were responsible for accelerating turbidity concentration on stream.

4.1.1 Turbidity and TSS

High mean concentration of turbidity and TSS in streams were analysed during autumn flood (Table 3-1). Turbidity and TSS measured in this investigation showed close relationship.

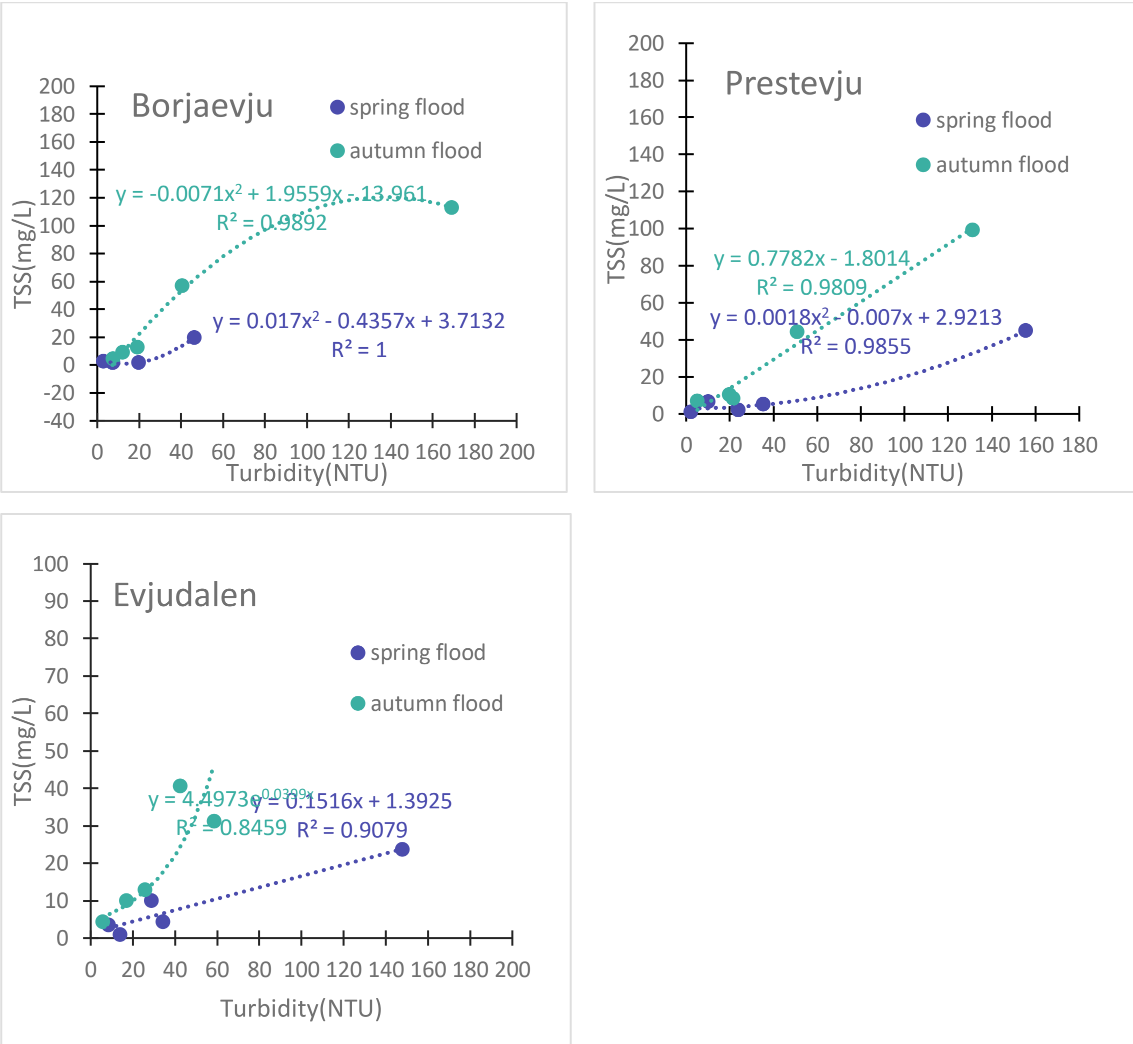


Figure 4-4 Relationship between TSS and turbidity on Borjaevju, Prestevju and Evjudalen stream

Figure 4-4 elaborates the relationship of TSS with turbidity during varying hydrological events in different streams. In Borjaevju, turbidity and TSS showed strong relationship in both flooding event; spring flood (R^2=1) and autumn flood (R^2= 0.98). Similary; in Prestevju, relationship of turbidity and TSS represented R^2 =0.98 during both flood which symbolize turbidity and TSS were correlated. Like Borjaevju and Prestevju; turbidity and TSS concentration in Evjudalen demonstrated strong relationship (R^2>0.80). Thus, turbidity and TSS symbolized strong relationship and turbidity and be used as good predictor of TSS in this investigation.

4.1.2 Colour

Maximum monthly mean concentration of colour on all study sites was analysed in autumn flood (Table3-1). Among study sites, highest amount of colour was found in Borjaevju stream.

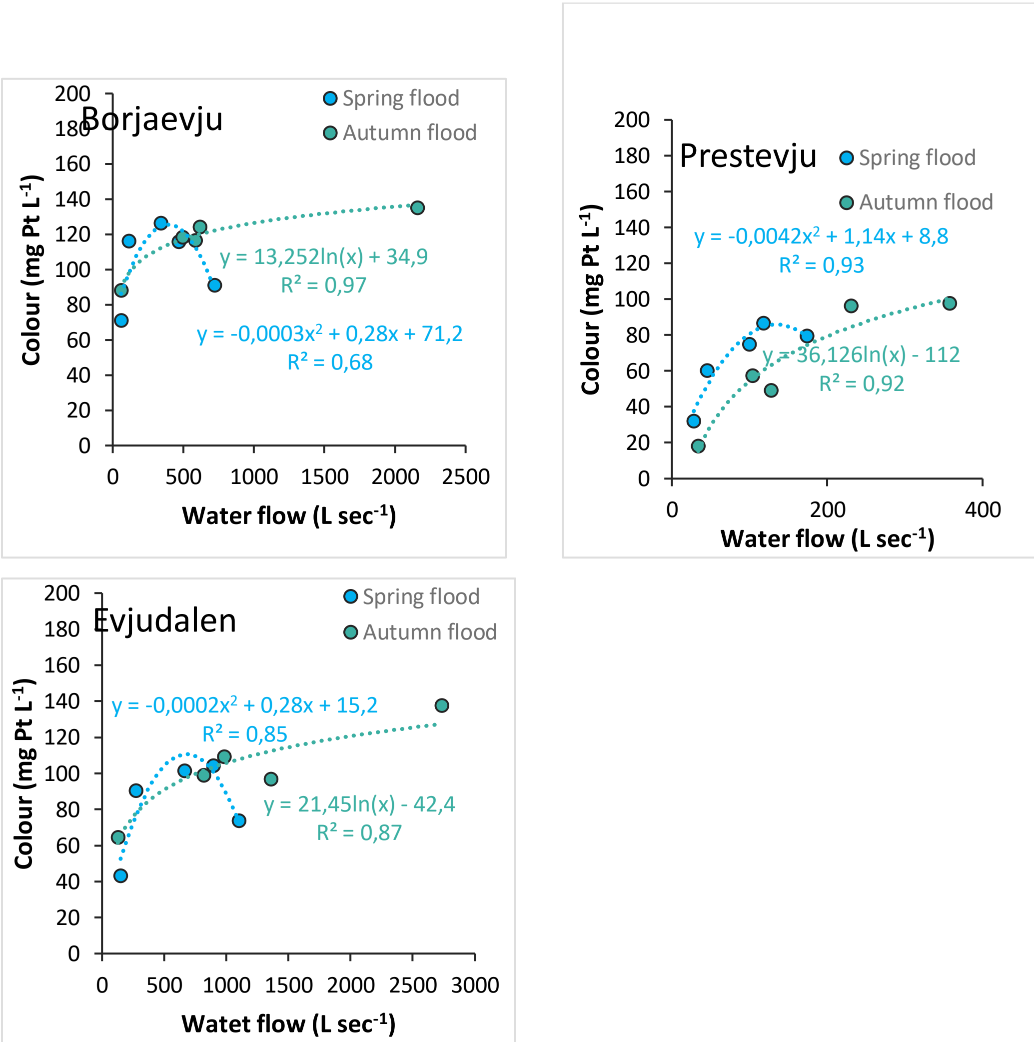


Figure 4-5 Relationship between water flow and colour on Borjaevju, Prestevju and Evjudalen stream during flooding events

Figure 4-5 shows the relationship of water flow and colour during spring and autumn flood. In Borjaevju, water flow and colour indicated strong relationship during autumn flood (R^2=0.97) and average relationship was analysed during spring flood (R^2=0.68). Similarly; in Prestevju, colour concentration increases according to amount of water flow. Discharge and colour amount in Prestevju demonstrated strong relationship (R^2>0.90). Likewise, in Evjudalen, colour and water flow showed strong relation and supported the information conceived from rest of two stream. Overall, waterflow and colour concentration demonstrated strong relationship in all streams during both flooding events.

4.1.3 Total Phosphorus

The maximum monthly mean concentration of total phosphorus on all sampling sites was analysed in May followed by October. Among sampling sites, Prestevju (92.4 µg L^{-1}) followed by Borjaevju (77.8 µg L^{-1}) had highest mean concentration of total phosphorus (Table 3-1). The percentage of P-fractions played vital role on transportation and retention in dams. The amount of dissolved P (66.4%) in this investigation was almost doubled than Part-P.

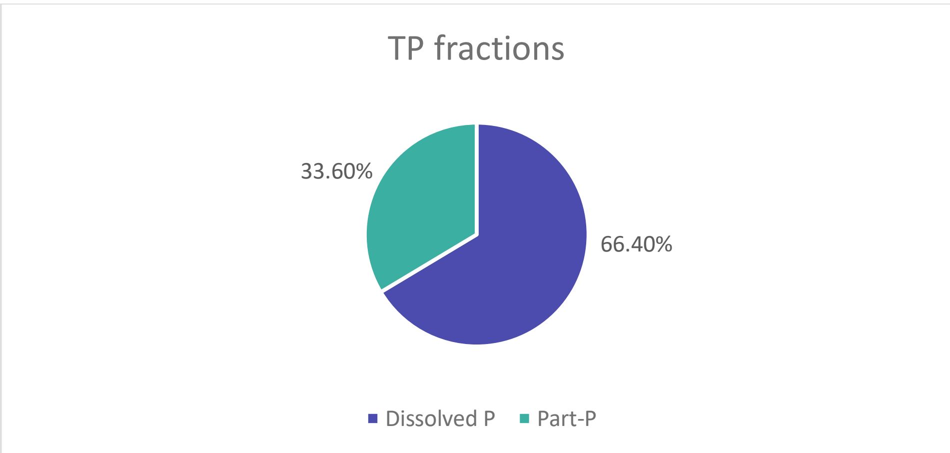


Figure 4-6 Percentage of P fractions in TP

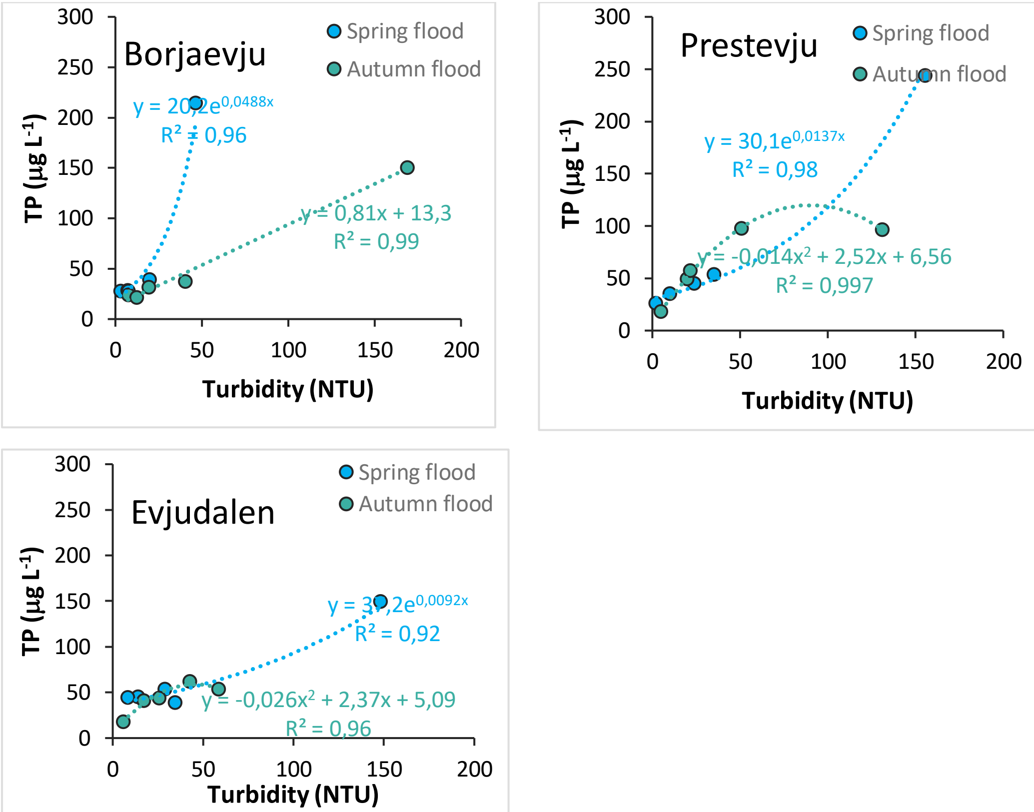


Figure 4-7 Relationship between TP and turbidity on Borjaevju, Prestevju and Evjudalen stream during flooding events

Figure 4-7 explains the relationship of TP with turbidity in sampling sites during two flooding events. In Borjaevju, turbidity and TP represented strong relationship in spring flood (R^2=0.96) and autumn flood (R^2=0.99). There was drastic rise in concentration of TP during spring flood however, autumn flood demonstrated gradually increment of TP. In Prestevju, spring flood demonstrated highest amount of TP. Autumn flood showed gradual rise in TP concentration and spring flood represented extreme rise in TP amount. Both hydrological events demonstrated strong relationship of TP and turbidity. Like Prestevju and Borjaevju, two flooding events demonstrated strong relationship between TP and turbidity in Evjudalen (R^2>0.90). Therefore, TP and turbidity were closely related during both flooding events and turbidity can used as predictor of TP.

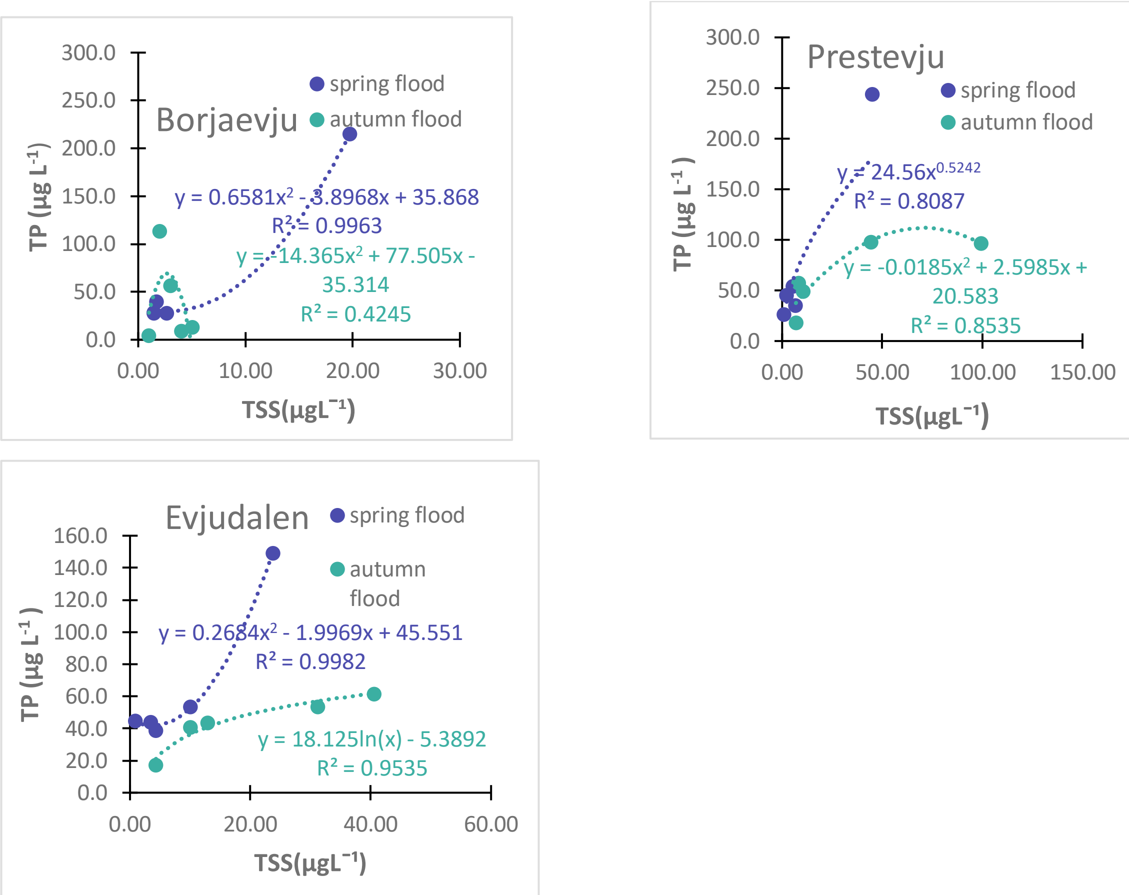


Figure 4-8 Relationship between TP and TSS on Borjaevju, Prestevju and Evjudalen stream during flooding events

Figure 4-8 elaborates relationship of TP and TSS in study area during both hydrological events. In Borjaevju, spring flood demonstrated strong relationship (R^2=0.99) between TP and TSS. However, autumn flood represented weak relationship (R^2=0.42) and outlier observed during autumn flood signifies role of excessive discharge to migrate high flux of particles. In Prestevju, there was drastic rise of TP during spring flood and outlier on TP concentration signifies high flow of phosphorus concentration during extreme flooding period. Both spring (R^2=0.80) and autumn (R^2=0.85) floods demonstrated strong positive relationship between TP and TSS concentration. Similarly, TP and TSS amount in Evjudalen represented strong positive relationship in both hydrological events. Overall, TP and TSS concentration were closely associated in both flooding events.

Water chemistry fluctuated during different seasonal variation. To understand TP association with soil particles during spring flood and autumn flood, ratio of P with turbidity and TSS was calculated.

Table 4-1 TP concentration ratio to TSS and turbidity in three streams during both hydrological events

Ratios	Flooding event	Borjaevju	Prestevju	Evjudalen
TP/TSS	Spring flood	13.56275076	6.447075812	8.767024
	Autumn flood	1.622132343	1.974766285	2.403676
TP/Turbidity	Spring flood	4.01904664	1.988697042	1.788425
	Autumn flood	1.256028676	1.533691286	1.620517

The amount of phosphorus flow along with soil particles from watershed can be represented in Table 4-1. Spring flood demonstrate high TP/TSS and TP/turbidity ratio. So, maximum P concentration was eroded from catchment during spring season.

4.1.4 Total Nitrogen

Monthly mean concentration of Tot- N on is highest in May (Table 3-1). Among sampling sites, Prestevju (N=6134 µg L^{-1}) stream represented highest mean concentration of total nitrogen followed by Evjudalen stream (N= 4743.9 µg L^{-1}). Similarly; Prestevju demonstrated maximum concentration of N-fractions (dissolved N, Part-N, Org. N and NO^{3-}) during spring flood. The amount of dissolved N measured in this investigation was approximately triple the concentration of Part-N.

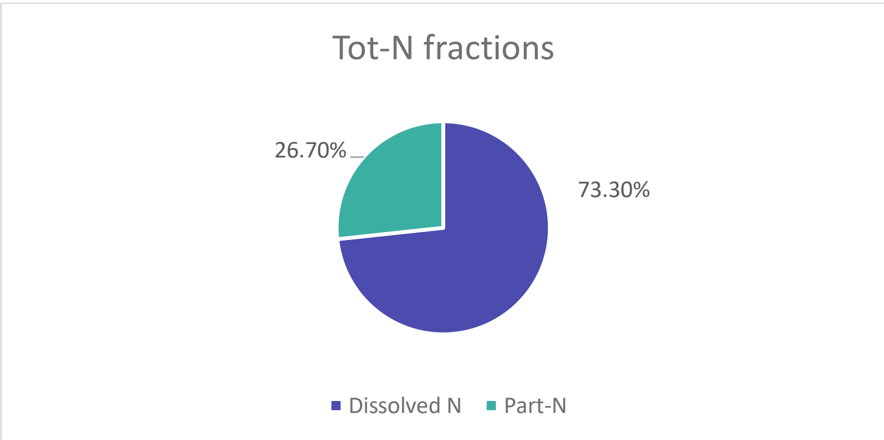
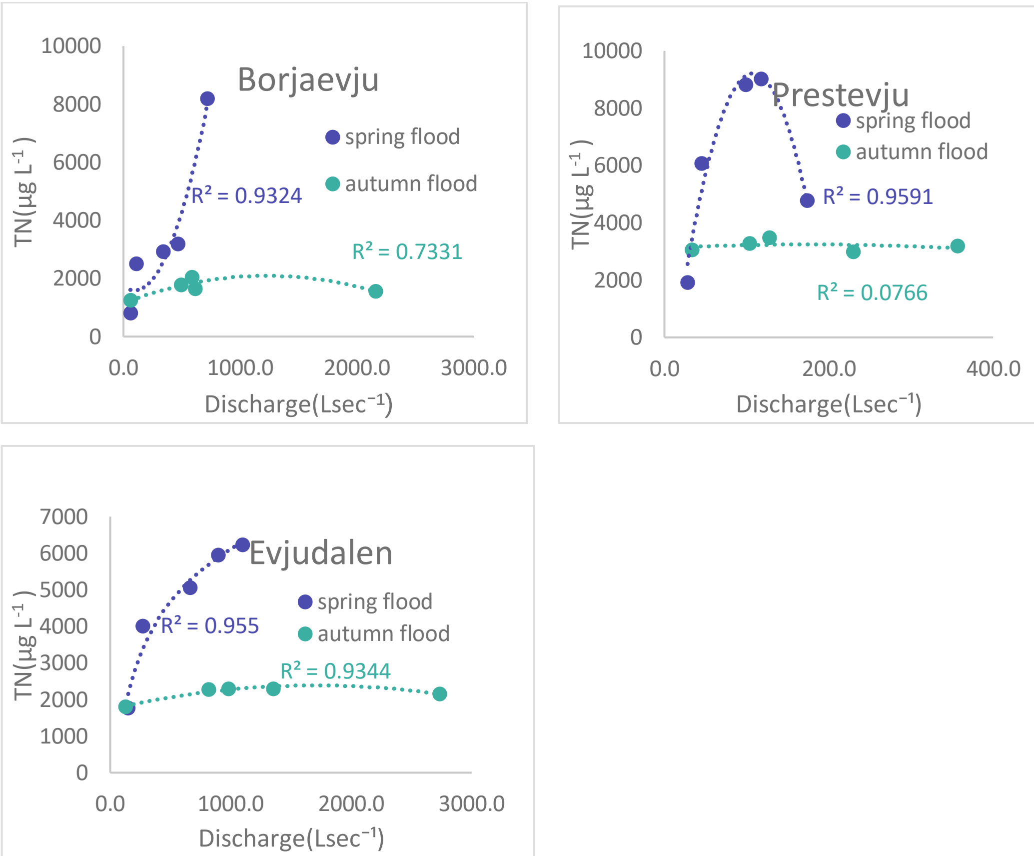


Figure 4-9 Percentage of N-fractions in TN



.Figure 4-10 Relationship of TN and discharge in Borjaevju, Prestevju and Evjudalen during two hydrological events

Figure 4-10 describe the relation of discharge with TN in three streams during spring and autumn flood. In Borjaevju, spring flood showed drastic rise of nutrient concentration and strong relation (R^2=0.93) was analysed. However, autumn flood demonstrated moderate relationship (R^2=0.73) of discharge and TN. In Prestevju, spring flood demonstrated very strong relationship (R^2=0.95) of discharge and TN however, autumn represented very weak relationship. According to the Figure 4-10; Evjudalen demonstrated strong relationship (R^2> 0.90) between discharge and TN on both flooding events. S, discharge demonstrated significant relation on three streams on both flooding events especially in spring flood. Thus, nitrogen concentration increased in stream as the amount of water flow increases.

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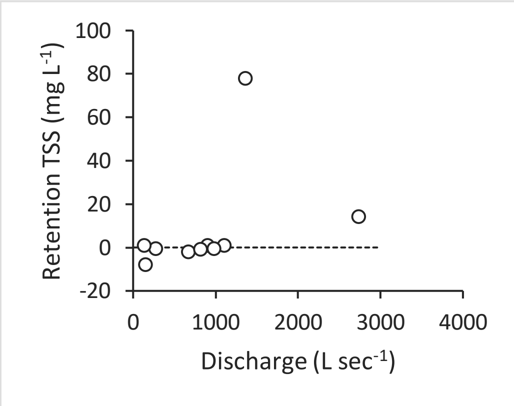
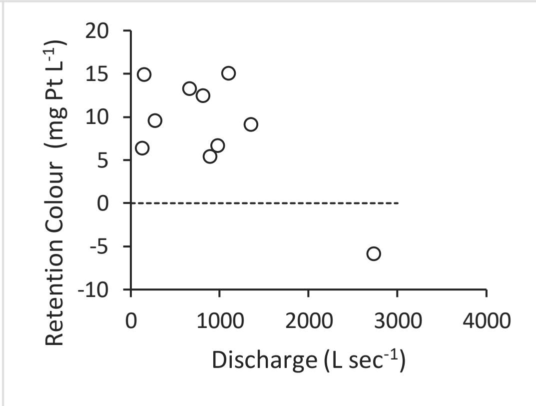
4.2 Retention of particles and nutrients

The retention of particles and nutrients on dams was due to function of water velocity, and soil particles. Amount of water flow showed significant effect for retaining nutrient on Dam A, B and C.



a)



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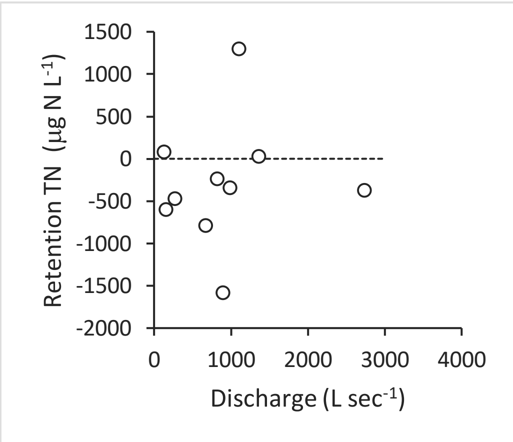

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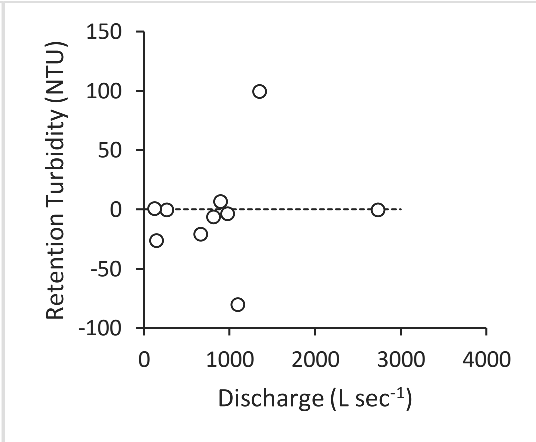

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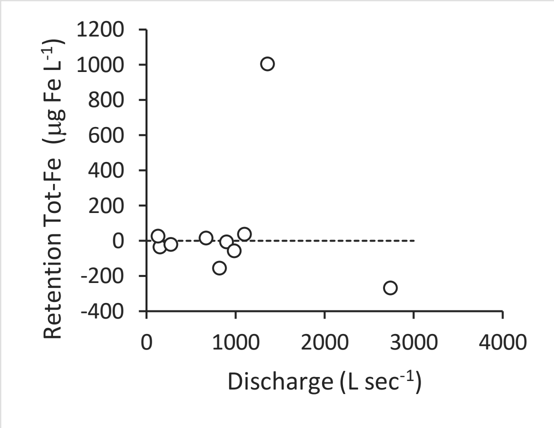
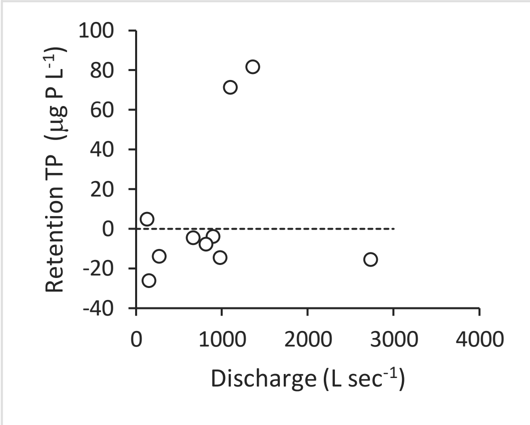


e)



f)

Figure 4-11 Relationship of discharge with retention of particles like a) TSS b) Colour c) TN d)Turbidity e) Fe f) TP

Figure 4-11 explains the relationship of discharge concentration with water quality parameters. Retention of turbidity, TSS and colour was observed during low to medium flood up to 1000 $Lsec^{-1}$. Nutrients (TN and TP) could not be retained at high amount of water flow. Basically, these nutrients were retained on dams due to sedimentation of particles, and retention of particle was observed clearly during low and medium discharge. Similarly, retention of Fe was analyzed up to 1000 $Lsec^{-1}$. Thus, this investigation showed retention ponds can effectively retain particles and nutrients at low or medium flood.

As mention above there was close relation of TP with turbidity and TSS so this investigation attempted to comprehend relationship of retention of Part-P with soil particles retained in dams.

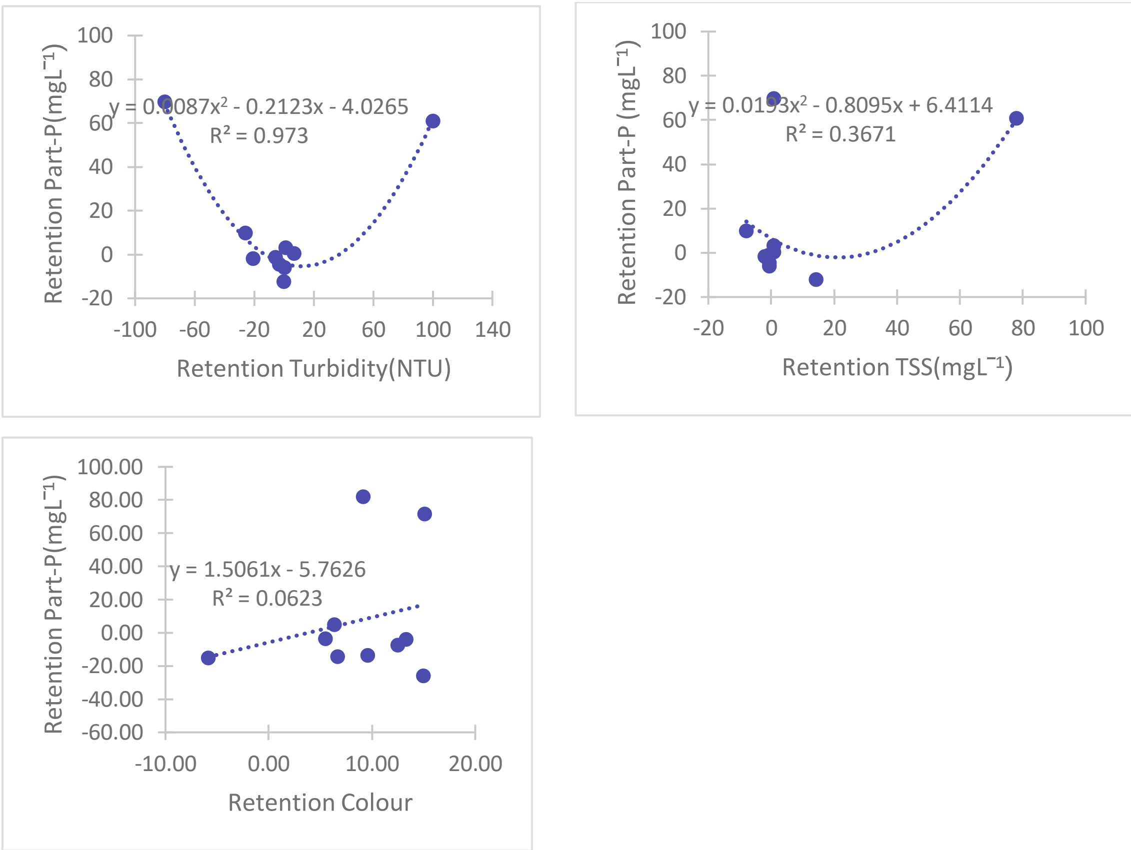


Figure 4-12 Relationship of retention Part-P with retention turbidity, retention TSS and retention colour

Figure 4-12 shows relationship of Part-P retention and particles retention. Retention of Part-P showed strong relationship(R^2=0.97) with retention of turbidity. Retention of TSS showed average relationship (R^2=0.36) with Part-P retention. However, there was very weak relationship (R^2=0.06) between retention of Part-P and colour retention. Overall, turbidity showed best relationship with Part-P. So, retention of turbidity demonstrated good predictor for Part-P retention.

4.3 Analytical Evaluation of Stream Water Parameter

Minitab 18 computed correlation and One-Way ANOVA test which demonstrated relationship among parameters and significant difference on study sites respectively.

Table 5-1 Pearson Correlation coefficient between water quality parameters on Borjaevju, Prestevju & Evjudalen stream.

		Discharge			pH			Conductivity			Turbidity			TSS			Colour		
C3:V32aramete	Floods	Borjaevju	Prestevju	Evjudalen	Borjaevju	Prestevju	Evjudalen	Borjaevju	Prestevju	Evjudalen	Borjaevju	Prestevju	Evjudalen	Borjaevju	Prestevju	Evjudalen	Borjaevju	Prestevju	Evjudalen
*pH	spring	0.165	**-0.902**	-0.026															
	autumn	-0.632	-0.485	-0.780															
*Conductivity	spring	-0.520	-0.794	-0.423	0.463	**0.945**	**0.893**												
	autumn	-0.739	-0.805	-0.781	**0.897**	0.037	0.745												
Turbidity	spring	**0.922**	0.870	0.653	0.495	-0.598	0.396	-0.230	-0.528	0.221									
	autumn	0.042	0.563	0.671	0.465	-0.745	-0.661	0.335	-0.484	-0.676									
TSS	spring	0.768	0.770	0.410	0.675	-0.476	0.576	0.114	-0.444	0.490	0.924	**0.980**	**0.953**						
	autumn	0.317	0.612	**0.929**	0.294	-0.814	-0.743	0.146	-0.451	-0.696	**0.959**	**0.990**	0.869						
*Colour	spring	0.123	0.820	0.453	**-0.878**	**-0.984**	-0.747	-0.483	**-0.976**	**-0.926**	-0.136	0.484	-0.252	-0.381	0.368	-0.524			
	autumn	0.793	**0.908**	**0.923**	-0.728	-0.120	-0.768	**-0.883**	**-0.945**	**-0.903**	0.144	0.366	0.515	0.320	0.372	0.751			
Tot-P	spring	0.817	0.832	0.614	0.625	-0.543	0.542	0.040	-0.475	0.344	**0.953**	**0.996**	**0.976**	**0.996**	**0.991**	**0.954**	-0.308	0.425	-0.299
	autumn	-0.047	**0.917**	**0.896**	0.536	-0.530	-0.779	0.407	-0.867	-0.940	**0.996**	0.784	**0.846**	**0.931**	0.788	**0.895**	0.065	0.858	**0.884**
Dissolved P	spring	0.853	0.408	-0.401	0.323	-0.493	0.814	-0.121	-0.727	0.955	**0.932**	0.434	0.315	0.853	0.492	0.571	0.113	0.563	-0.852
	autumn	0.375	**0.938**	0.862	0.227	-0.324	-0.759	0.010	**-0.951**	**-0.959**	**0.929**	0.616	0.836	**0.980**	0.617	0.857	0.443	**0.958**	0.874
Part. P	spring	0.794	0.808	0.738	0.663	-0.482	0.418	0.066	-0.362	0.177	**0.937**	**0.978**	**0.983**	**0.999**	**0.961**	**0.909**	-0.372	0.342	-0.150
	autumn	-0.282	0.466	0.819	0.663	**-0.898**	-0.605	0.595	-0.256	-0.306	**0.944**	**0.934**	0.546	0.819	**0.945**	0.848	-0.155	0.205	0.557
Tot-N	spring	0.913	0.369	**0.930**	0.377	-0.712	-0.267	-0.147	-0.774	-0.630	**0.968**	-0.073	0.450	**0.921**	-0.202	0.168	-0.003	0.812	0.719
	autumn	0.066	-0.127	0.405	0.137	**0.921**	-0.563	-0.112	-0.315	**-0.882**	0.773	-0.540	0.568	0.715	-0.602	0.372	0.495	0.234	0.612
Dissolved N	spring	0.908	0.687	**0.972**	0.388	**-0.923**	-0.071	-0.120	**-0.894**	-0.453	**0.960**	0.261	0.622	**0.936**	0.113	0.371	-0.039	**0.959**	0.546
	autumn	-0.108	-0.154	0.099	0.489	**0.911**	-0.532	0.351	-0.363	-0.542	**0.976**	-0.492	0.616	**0.885**	-0.577	0.240	0.116	0.258	0.187
Part-N	spring	0.887	0.085	0.740	0.320	-0.472	-0.575	-0.232	-0.596	-0.861	**0.951**	-0.321	0.093	0.830	-0.421	-0.208	0.117	0.610	**0.933**
	autumn	0.316	0.047	0.540	-0.646	0.303	-0.405	-0.842	0.063	**-0.889**	-0.392	-0.315	0.339	-0.331	-0.257	0.366	0.680	-0.009	0.783
Org-N	spring	0.934	0.210	0.811	0.342	-0.570	-0.485	-0.199	-0.686	-0.806	**0.969**	-0.193	0.186	**0.907**	-0.301	-0.115	0.024	0.696	**0.887**
	autumn	0.330	0.259	0.501	-0.385	-0.295	-0.859	-0.718	0.264	-0.805	-0.079	-0.194	0.523	-0.028	-0.061	0.433	0.694	-0.012	0.660
*Ca^{+2}	spring	0.706	**-0.881**	-0.489	0.651	**0.960**	0.762	0.226	**0.985**	**0.961**	0.889	-0.661	0.271	**0.983**	-0.576	0.550	-0.319	**-0.963**	**-0.963**
	autumn	-0.765	-0.803	-0.770	**0.897**	0.060	0.690	**0.999**	**0.999**	**0.982**	0.306	-0.515	-0.535	0.111	-0.481	-0.620	**-0.897**	-0.936	**-0.934**
*Mg^{+2}	spring	0.755	**-0.896**	-0.586	0.562	**0.936**	0.711	0.161	**0.961**	**0.947**	**0.905**	-0.730	0.162	**0.973**	-0.667	0.454	-0.212	**-0.925**	**-0.963**
	autumn	-0.732	-0.835	-0.810	**0.922**	0.018	0.689	**0.983**	**0.992**	**0.961**	0.478	-0.410	-0.492	0.278	-0.389	-0.635	-0.795	**-0.974**	**-0.964**
*Na^{+}	spring	-0.448	-0.610	-0.708	0.736	0.876	0.591	**0.918**	**0.950**	0.863	-0.103	-0.245	-0.067	0.225	-0.144	0.231	-0.770	**-0.949**	**-0.945**
	autumn	-0.755	-0.767	-0.760	0.765	0.032	0.714	**0.933**	**0.996**	**0.998**	-0.021	-0.519	-0.634	-0.189	-0.477	-0.659	**-0.988**	**-0.913**	**-0.901**
*K^{+}	spring	0.830	-0.551	-0.167	0.578	0.842	0.813	0.030	**0.931**	**0.894**	**0.942**	-0.182	0.547	**0.992**	-0.091	0.767	-0.278	**-0.925**	**-0.946**
	autumn	0.059	0.201	-0.002	0.486	-0.497	-0.103	0.336	0.074	0.188	**0.998**	0.514	0.591	**0.964**	0.570	0.357	0.139	-0.121	-0.324
*SO_4^{-2}	spring	0.468	-0.776	**-0.973**	0.569	0.573	0.156	0.410	0.502	0.498	0.720	-0.787	-0.677	0.804	-0.686	-0.423	-0.154	-0.496	-0.517
	autumn	-0.778	**-0.888**	-0.797	0.390	0.083	**0.999**	0.737	**0.972**	0.763	-0.077	-0.397	-0.666	-0.272	-0.393	-0.754	-0.786	**-0.994**	-0.788
*Cl^{-}	spring	0.257	-0.627	-0.699	0.840	0.877	0.573	0.659	**0.962**	0.837	0.562	-0.284	-0.087	0.814	-0.188	0.205	-0.637	**-0.948**	**-0.938**
	autumn	-0.678	-0.784	-0.783	0.765	0.023	0.734	**0.940**	**0.999**	**1.000**	0.044	-0.489	-0.677	-0.102	-0.451	-0.699	**-0.963**	**-0.932**	**-0.903**
*NO_3^{-}	spring	**0.903**	0.559	0.969	0.391	-0.851	-0.047	-0.125	-0.833	-0.422	**0.967**	0.097	0.658	**0.927**	-0.049	0.414	-0.015	**0.908**	0.513
	autumn	-0.250	-0.211	-0.293	0.518	**0.878**	0.708	0.578	-0.367	0.108	**0.891**	-0.365	-0.078	0.780	-0.469	-0.218	-0.150	0.197	-0.264

**indicates a significant relationship ($P<0.05$) of parameter among streams (ANOVA)*

Tot- P showed significant positive relation with turbidity and TSS. Discharge concentration in Prestevju (r= 0.908) and Evudalen (r= 0.896) during autumn flood showed significant positive relation with TP. Additionally, TP represented significant positive relation with colour in Evjudalen (r=0.884) during autumn flood. Dissolved P was not able to demonstrate good relationship with turbidity and TSS. In contrast; Part-P demonstrated good relationship with turbidity and TSS. Unlike to TP, N-fractions did not demonstrate good relationship with water parameters. Some significant relationship was analyzed on spring flooding event. Tot- N measured during spring flood was significantly related with discharge in Evjudalen (r=0.972), and turbidity(r=0.908) & TSS (r=0.921) in Borjaevju. Colour showed significant negative relation with conductivity except in Borjaevju during spring. Cations (Mg^{+2}, Na^{+}, K^{+} & Ca^{+2}) and anions (SO_4^{-2}, NO_3^{-}) demonstrated strong relationship with conductivity.

One-Way ANOVA shows statistically significant test of water quality parameters on three streams (Borjaevju, Prestevju and Evjudalen). According to One-Way ANOVA, mean concentration of pH, conductivity, and colour represented statistically significance. Among N-fractions, only NO_3^{-} on streams was statistically significant. Additionally, mean concentration of cations and anions demonstrated significant difference on study area However, P-fractions like dissolved P and particulate P demonstrated statistical insignificance. Similarly, heavy metals on streams represented statistically insignificance. Basically, Turkey Pairwise Comparison demonstrated that parameters were statistically significant between Borjaevju and Prestevju

5. Discussion

5.1 Water Chemistry During Hydrological Events

Two flooding events (spring and autumn flood) were responsible for transportation of high amounts of particles and nutrients. Similarly, a research carried out in east central Sweden which demonstrated that a seasonal deposition in constructed wetland (Nyb) was strongly correlated with Fast Flow Index (FFI) and suggested that this relationship signifies fast flow variations is responsible for excessive erosion and transportation of particles (Geranmayeh, Johannesson, Ulén, & Tonderski, 2018). Large flow variation indicates more flooding events, that are erosive in nature, especially in small stream (Veihe, Jensen, Schiøtz, & Nielsen, 2011). In this investigation, flooding events (spring and autumn flood) transported high concentration of nutrients (N and P) from catchment to stream; especially spring flood carried maximum nutrient concentration. Similarly, a study conducted in Sweden demonstrated phosphorous was proportionally related with water flow velocity like high concentration of phosphorus is found in higher flow rate (Barbro Ulén, Carlsson, & Lidberg, 2004). Moreover, a research conducted in south- eastern Norway suggested that high amount of water flow and total phosphorus conveyance can be analysed during snow melting period (April-May) and in rainy season after heavy precipitation (Krogstad & Løvstad, 1989). Likewise; a study conducted in Northern Great Plains in Canada suggested that total phosphorus concentration was measured highest in snowmelt period than in rainy seasons, whereas; concentration of total nitrogen was low in snowmelt seasons than rainfall seasons. Thus, N & P ratio on all catchments were relatively low during autumn period (Wilson, Casson, Glenn, Badiou, & Boychuk, 2019). A research conducted on Sweden demonstrated spring season (March-May) responsible for highest seasonal mean concentration of phosphorus at main entrance (Johannesson, Andersson, & Tonderski, 2011). Thus; there is extreme change in water quality during hydrological events, and spring flood carries high amount of nutrients from catchment.

Present study forwards idea on hydrological events behave differently for particle transportation; such as autumn flood transported high concentration of TSS. This result can be identical with study conducted in Canada, which have similar climatic features as Norway. Jensen et al. (2011) conducted a research in Northern Great Plains in Canada, found that total suspended solids and particulate nutrients concentration was maximum on rainy season; whereas, dissolved nutrient concentration was high on spring season (snow melting period). The reason of excessive transport of solid particles during autumn may be due to maximum precipitation and some agricultural practices such as tillage or ploughing. In Norway, it was primitive farming practice to plough field up to 20cm deep during September or October. Such ploughing keeps land bare in the occasion of highest precipitation (Bechmann & Øgaard, 2013). Thus, there is significant role of autumn rainfall and runoff for tillage effect on solid particles in arable stream (ØYGARDEN, 2006). Overall, the land use pattern and management strategy can proportionally affect the soil erosion and nutrient wash out.

Concentration of conductivity on Borjaevju, Prestevju and Evjudalen show strong correlation with cations and anions. Similarly, a case study in Chini Lake showed ions like sulphate ($r=0.311$ & $P<0.001$) and nitrate ($r=0.311$ & $P<0.001$) have significant positive relationship with conductivity (Shuhaimi-Othman et al., 2007). Highest conductivity and ions concentration were measured on Prestevju which means higher agricultural coverage and surplus urban areas can rise the ionic strength in water bodies. Moreover; in this research, maximum conductivity is measured in autumn flood and minimum in spring flood. Similarly; a study conducted in Bialka River Catchment in Southern Poland found that low conductivity and low concentration of ions NH_4^+, NO_3^-, NO_2^-, and PO_4^- were recorded on snowmelt season (spring) (Lenart-Boroń, Wolanin, Jelonkiewicz, & Żelazny, 2016). During snowmelt seasons; low conductivity and ion content is the result of water dilution due to melting of snow (Ahearn, Sheibley, Dahlgren, & Keller, 2004). So, water dilution may be cause of low conductivity observed during spring flood.

Geology of catchment, slope gradient or management system causes water quality variation on three streams. A study conducted in Oslo region of Norway suggested that geology and land use have significant impact on stream water quality (Reimann et al., 2009). Thus; in the present study, Borjaevju, Prestevju and Evjudalen show variation on water parameter especially on water flow amount, concentration of nutrient, and ions. Prestevju demonstrated maximum concentration of phosphorus and nitrogen as well as ions. Catchment characteristics may have significant effect on amount of nutrient flow on streams. The agricultural coverage is greater in Prestevju so there may be high possibility of transportation of nutrients and ions in streams. A study conducted in Norway showed that maximum hydraulic load is seen in agricultural catchments which may increase nutrient concentration in stream water (B. Braskerud, 2002). A study conducted in Slovakia suggested that there is greater chance of transportation of nitrate, phosphate, and ions like SO_4^{-2} and Cl^- from agricultural catchment. Moreover, wastewater from urban sewage accelerates the phosphorus pollution in water bodies (Pekárová & Pekár, 1996). A study conducted by Chilton et al. (1999) suggested that agricultural practice of applying artificial fertilizer on arable land releases K, P, N, Mg, Zn, SO_4^{-2} and Cl^-. Thus, high percentage of agricultural and urban influence have enhanced nutrients and ions concentration in Prestevju stream.

In the present study, discharge showed significant role on rise and fall of turbidity, TSS and TP. A study conducted in Lake Vansjø catchment in Norway suggested that TSS and TP response quickly to water flow variation than Dissolve Reactive Phosphorus (Bechmann & Øgaard, 2013). This investigation concludes that there is strong relation between turbidity and concentration of total phosphorus. Likewise; a study conducted by Schilling, Kim, & Jones (2017) on 43 various sites of river demonstrated that turbidity and total phosphorus were strongly correlated (r= 0.78). Moreover, a study conducted by Stubblefield et al. (2007) suggested that turbidity have strong correlation with TP and TSS. Basically, turbidity is site- specifically correlated with suspended solids and TP and this could not be interchanged between catchment(Marc Stutter et al., 2017). This emphasized that catchment characteristics have vital role for transport of particles and nutrients. For illustration, a study conducted in 108 monitoring sites in Sweden by Villa et al. (2019) showed that 87% of total sites or 94 sites (site-specific relationship) illustrated significant relationship ($P<0.05$) between turbidity and SS and this study also suggested that insignificant relationship was noticed on forest catchment sites. This investigation concludes that turbidity has strong relationship with TSS and TP in Evjudalen catchment.

The mean concentration of TP in this investigation range from 17.2 (µg/L) to 92.4 (µg/L) which is relatively low than a study conducted in Lake Vansjø in south eastern Norway that demonstrated concentration of TP from 85(µg/L) to 257 (µg/L) (Bechmann & Øgaard, 2013). This investigation also suggests that TSS and TP are significantly correlated. Similarly, Steegen et al. (2001) recommended that P concentration is strongly correlated with TSS because phosphorus discharge is proportional with erosion. Comparably, a study conducted in six agricultural streams of Lake Vansjø catchment in south eastern Norway recommended that most of the investigated streams represented strong relationship between TSS and TP (Bechmann & Øgaard, 2013). In the present study, Part- P show proportional relationship with suspended solids than dissolved P. This result can be comparable with investigation on same climatic region (Sweden). A study conducted in four constructed wetlands in east-central Sweden demonstrated that Part-P demonstrated strong linear relationship and high coefficient of determination with TSS (Geranmayeh et al., 2018). In this investigation, spring flood have high ratio value of TP concentration in soil particles. Additionally, Prestevju demonstrated high amount of TP transportation in stream. So, this study can suggest that agricultural practices (fertilizer application) can accelerated TP concentration in eroded soil particles. Similar to present study, a study conducted in Lake Vansjø in Norway suggested that TP/TSS relationship was maximum on those catchment which have higher percentage of agricultural land (Bechmann & Øgaard, 2013). They also suggested that supplement factors such as application of fertilizer (especially P), sewage system drainage from human settlement, or animal husbandry practices in watersheds are responsible for fluctuations in TP concentration (Bechmann & Øgaard, 2013). So, the variation of phosphorus concentration in water bodies is significantly due to eroded particles from catchment and anthropogenic factors.

Dissolved nitrogen concentration (73.3 %) is higher than particulate nitrogen in this investigation. Nitrogen was one of the major nutrient loss from catchment. In this investigation NO_3^- show maximum concentration in streams. Agricultural land may have accelerated NO_3^- amount in water bodies. This can be supported by a study conducted in Po Valley in Italy which suggested that NO_3^- is major N fractions transported from agricultural catchments (Ventura et al., 2008). Our result demonstrated highest monthly mean concentration of Nitrogen on spring flood; which is comparable with a study conducted in Skuterud catchment that showed two high peaks of monthly mean concentration of Total nitrogen in May (8.4 mgL^{-1} or 8400 µg L^{-1}) and October (7.2 mgL^{-1} or 7200 µg L^{-1}) (X. Chen & Bechmann, 2019). Additionally, our study also demonstrated highest month mean nitrate concentration on May followed by October. Comparably, monthly mean concentration of Nitrate in Skuterud catchment was found highest in May (6.9 mgL^{-1} or 6900 µg L^{-1}) and October (5.8 mgL^{-1} or 5800 µg L^{-1}) (X. Chen & Bechmann, 2019). This signifies that increasing water flow amount in stream tends to transport excessive amount of nitrogen from adjacent watershed; and especially NO^{3-} transportation is greater from arable land. Prestevju show higher concentration of nitrogen than Borjaevju. In the present study, Prestevju has greater coverage of agricultural land which may accelerate the nutrient concentration. For illustration, agricultural catchment shows high flow of total nitrogen into stream than from urban areas (Tong & Chen, 2002). Moreover, surplus factors like geology, human interference and sewage may have triggered nitrogen loads in Prestevju stream. A study conducted in Norway also suggested that soil types, climate, agricultural practices and land use can contribute for variation in N dynamics(X. Chen & Bechmann, 2019). Moreover, suggested strong correlation was noticed between total nitrogen and runoff on Skuterud (r^2= 0.65) and Naurstad (r^2= 0.38) catchment. Similarly, our study demonstrates total nitrogen and discharge were proportionally related during both floods. Overall, nutrient transportation varies according catchment characteristic, water flow amount and climatic condition.

5.2 Retention of particles and nutrients

This study interpreted discharge as major factor for determining retention of particle. Retention of particles and nutrient were observed during low and medium flood. Evjudalen showed lower concentration of TP than Borjaevju and Prestevju. Similarly, a study conducted in a stream incorporated with newly constructed wetlands in Sweden showed that mean concentration of TP was higher in inlet than outlet (Kynkäänniemi, Ulén, Torstensson, & Tonderski, 2013). In our result, retention of total phosphorus ranges from -25 µg L^{-1} to 81 µg L^{-1}. The positive value of retention may be the resultant for effect of dams and negativity may due to source of P in watershed nearby, or excessive rise in water amount and proportion of P fraction. The percentage of particulate and dissolve phosphorus directly influence retention of P and dissolved P concentration is greater than Part-P in this investigation. (Hoffmann, Kjaergaard, Uusi-Kämppä, Hansen, & Kronvang, 2009) suggested that usually efficacy of P retention in wetland is extremely related with entrance of P fractions (retention of DP is lower than PP). Additionally, a study conducted in CWs in central and southern Norway suggested that retention of Part-P was about 45% and dissolved P was only 5% (B. Braskerud, 2002). Sometimes mitigation measure of floods may result for sources of particles and its associated (e.g. geology, resuspension) which tends rise the nutrient concentration on water flow. For illustration, Buffer Zone enriched of phosphorus results negative phosphorus retention (B Ulén, 1988). In present study, the effect of dams for N retention was good during limited discharge concentration up to 1000 $Lsec^{-1}$. As discussed above, higher amount of water flow transport large amount of nutrients (N & P) from catchment. So, there is greater possibility of N concentration in stream during hydrological events which simultaneously increases N retention in dams. However, at excessive water flow amount retention dams could not play effective role on particles settlings. R. Kadlec et al. (2000) suggested that nitrogen retention is inversely proportional to hydraulic load. A study conducted in constructed wetland from south-eastern part of Norway demonstrated Nitrogen retention was found high on 2003 (17% N) than on 2004 (2%) because hydraulic load was maximum on 2004 (Blankenberg et al., 2008). Therefore, discharge is important factor for enriching nutrients on stream, and retention dams can actively interrupt soil particles and nutrients transportation at low to medium water flow.

6 Limitations:

Samples were collected on monthly basis especially focusing on at least two hydrological events on spring and autumn. So, small sample size may have caused some alteration on result interpretation. Moreover, sampling sites were determined randomly. This research has intended to measure colour concentration instead of TOC (Total Organic Carbon) due to lack of instrument for analysing TOC. Additionally, AAS analyser used for measuring heavy metals was not able to produce high quality of data presented. Total area of catchment and geomorphological study was not taken in consideration. Nutrient loading from catchment was not estimated so the retention load on dams was also not examined. This research does not focus on application of fertilizer on agricultural land and wastewater from urban areas.

7 Conclusion:

The nutrient concentration from catchment in stream varies spatially and temporally. Agricultural runoff is major cause of change in stream water chemistry. This study represents high amount of flow is represented during snow-melting season and rainy season. Similar to Krogstad & Løvstad (1989); spring flood and autumn flood carries higher concentration nutrient to stream. So, the surface runoff directly influences the stream water quality. Evjudalen represents higher discharge amount and minimum concentration of TP. Interestingly; smallest catchment area; Prestevju transported high concentration of nutrients and ions concentration. High coverage of arable land and greater urban influence can be major factor for hindering higher flux of nutrients in Prestevju stream.

Spring flood migrates higher concentration of TP and TN from catchment. The main reason could be fertilizing agricultural areas (especially N, P and K fertilizers) during spring. As like many researchers, this investigation has demonstrated strong relation between turbidity, TSS and TP. However, dissolved P does not demonstrate identical relationship with turbidity and TSS. Part-P demonstrate good association with turbidity and TSS. Distribution of turbidity, TSS and colour demonstrated simultaneous rise with discharge increment, so waterflow amount is main cause for fluctuation of particulates on water bodies. Present study represented autumn flood transport maximum concentration of TSS, turbidity and colour. So, autumn precipitation has higher erosive capacity to transport soil particles from catchment to stream. Additionally, land use practice influence the transportation of such particles.

This investigation has emphasized on retention of particles and nutrients. Clay soil has high influence on phosphorus adsorption (Sharpley, 1980). So, the clayey soil predominant in our study area suggest that phosphorus has greater possibility to be eroded and retained in dams. Among all parameters; turbidity, TSS, colour, TP, Fe and TN were retained in dams during low to medium waterflow. A study in Swedish P wetlands also demonstrated TP and TSS was effectively retained in wetland which suggests that such P wetlands were able to interrupt agricultural P loading (Kynkäänniemi et al., 2013). Among all N and P fractions, Part-P demonstrated effective retention. This investigation shows that turbidity retention can be important parameter for prediction of Part-P retention. Additionally, discharge concentration can significantly affect the amount of particles retention. Lower the amount of water flow then there is high possibility of sedimentation of particles. In this investigation, retention of particles is seen during lower and moderate flow i.e. flow up to 1000 $Lsec^{-1}$.

Water quality in stream is reflection of watershed characteristics and climatic condition. The land-use system in catchment significantly influence water quality parameters. Additionally, anthropogenic activities directly impact water bodies such as farming, livestock, sewage, and settlement. Rainfall and snow melt season are dominant factors for increase of runoff from catchment which proportional increases nutrients transportation. Phosphorus is major associated nutrients with soil particles (especially clayey soil) which have high possibility to be transported to downstream. Particles can be measured as turbidity and TSS. Turbidity can be the good predictor of TSS and TP. It is important to adopt strategic step to control these particles and it associated nutrients. The retentions ponds could be important mitigation measures to control nutrients flow to downstream. Higher proportion of particles is transported during flooding events so these dams could interrupt solid particles and its associated nutrients especially TP. Thus, these ponds could play vital role for minimizing eutrophication conditions in downstream water bodies.

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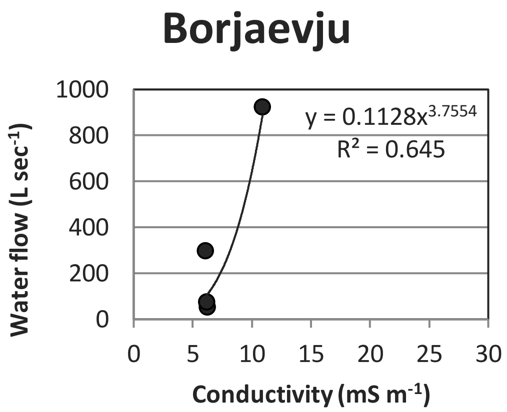
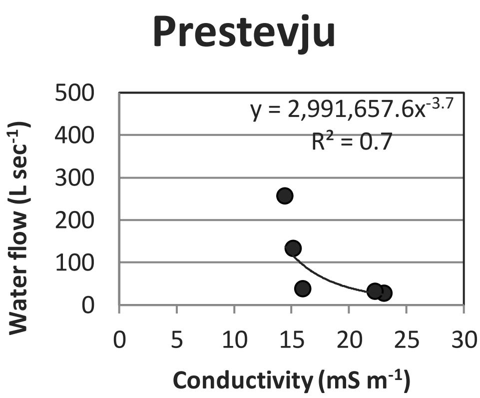
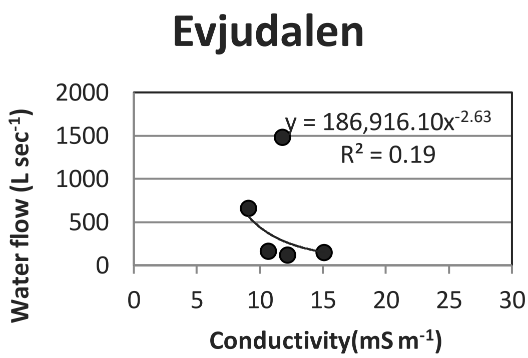
List of figures and tables

Annexes

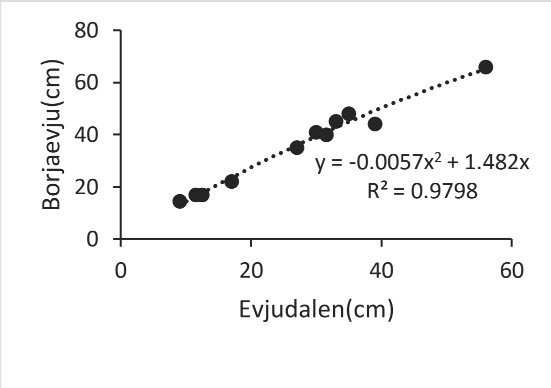
Annex 1: Relationship of water flow and conductivity in Borjaevju, Prestevju and Evjudalen streams.

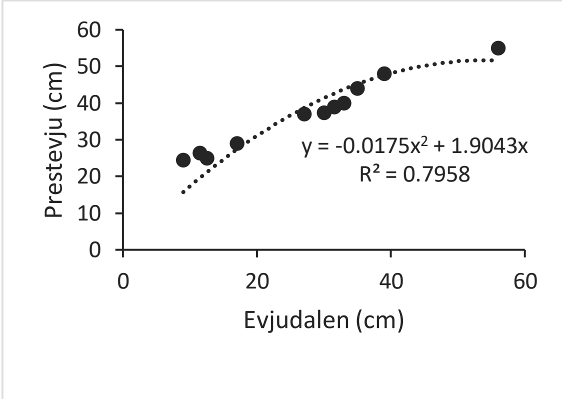


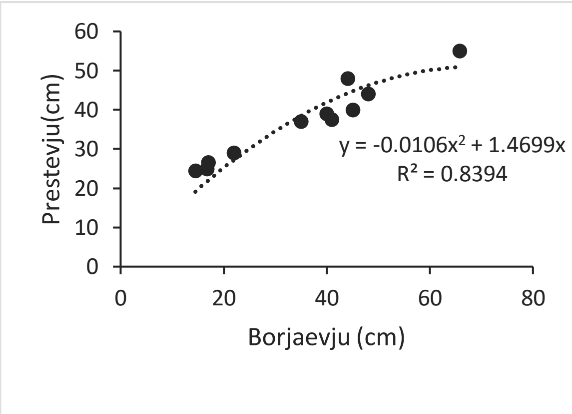




Annex 2: Relationship of water level among Borjaevju, Prestevju and Evjudalen streams.







Annex 3: Relation of discharge with parameters on Borevju stream.

	Regression Equation	R^2
pH	log10(pH_1) = 0.8443 - 0.000012 Discharge_1(L sec-1)	30.81 %
Conductivity	log10(Cond._1) = 1,799 - 0,000100 Discharge_1(L sec-1)	60.07 %
Turbidity	log10(Turbidity_1) = 0,9667 + 0,000448 Discharge_1(L sec-1)	28.22 %
TSS	log10(TSS_1) = 0,4792 + 0,000710 Discharge_1(L sec-1)	41.12 %
Colour	log10(Colour_1) = 1,994 + 0,000074 Discharge_1(L sec-1)	26.53 %
Ca	log10(Ca2+_1(mg L^{-1})) = 0.8429 - 0.000083 Discharge_1(L sec-1)	26.03 %
Mg	log10(Mg2+_1(mg L^{-1})) = 0.3198 - 0.000095 Discharge_1(L sec-1)	25.72 %
Na	log10(Na+_1(mg L^{-1})) = 0.4889 - 0.000128 Discharge_1(L sec-1)	61.68 %
K+ vs Disharge	log10(K+_1(mg L^{-1})) = 0.04136 + 0.000057 Discharge_1(L sec-1)	8.71%
SO_4^{-2}	log10(SO42-_1(mg L^{-1})) = 0.5492 - 0.000065 Discharge_1(L sec-1)	16.46 %

Cl-	log10(Cl-_1(mg L⁻¹)) = 0.5738 - 0.000053 Discharge_1(L sec-1)	17.22 %
TP	log10(TP_1(µg L⁻¹)) = 1.564 + 0.000110 Discharge_1(L sec-1)	3.82%
Dis. P	log10(Dis.P(µg L⁻¹)) = 1.298 + 0.000218 Discharge (L sec-1)	31.99 %
Part. P	log10(Part. P(µg L⁻¹)) = 1.204 - 0.000545 Discharge (L sec-1)	17.24 %
TN	log10(Tot N(µg L⁻¹)) = 3.304 + 0.000038 Discharge (L sec-1)	0.71%
Dis.N	log10(Dis. N(µg L⁻¹)) = 3.225 + 0.000030 Discharge (L sec-1)	0.54%
Part. N	log10(Part. N(µg L⁻¹)) = 2.241 + 0.000266 Discharge (L sec-1)	5.69%
Org. N	log10(Org N(µg L⁻¹)) = 2.627 + 0.000180 Discharge (L sec-1)	7.16%
NO3--N	log10(NO3--N_1(µg L⁻¹)) = 3.177 + 0.000001 Discharge_1(L sec-1)	0.00%
Fe	log10(Fe(µg L⁻¹)) = 2.503 + 0.000123 Discharge (L sec-1)	5.35%
Mn	log10(Mn(µg L⁻¹)) = 0.1456 + 0.000749 Discharge (L sec-1)	16.36 %
Zn	log10(Zn(µg L⁻¹)) = 0.9575 + 0.000233 Discharge (L sec-1)	19.89 %
Cu	log10(Cu(µg L⁻¹)) = - 0.8205 - 0.000044 Discharge (L sec-1)	0.30%

Annex 4: Simple Linear Regression Equation and R-squared value on Prestevju stream.

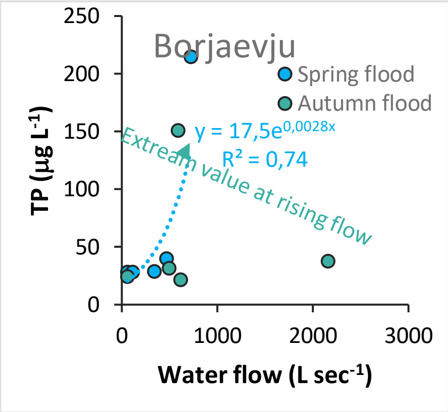
	Regression Equation	R^2
pH	log10(pH_2) = 0.8779 - 0.000105 Discharge_2 (L sec-1)	40.59 %
Conductivity	log10(Cond._2) = 2,262 - 0,001038 Discharge_2 (L sec-1)	74.08 %
Turbidity	log10(Turbidity_2) = 0,8147 + 0,004154 Discharge_2 (L sec-1)	52.89 %
TSS	log10(TSS_2) = 0,3597 + 0,004722 Discharge_2 (L sec-1)	56.91 %
Colour	log10(Colour_2) = 1,669 + 0,001254 Discharge_2 (L sec-1)	60.17 %
Ca	log10(Ca2+_2(mg L⁻¹)) = 1.174 - 0.000832 Discharge_2 (L sec-1)	75.46 %
Mg	log10(Mg2+_2(mg L⁻¹)) = 0.6773 - 0.000901 Discharge_2 (L sec-1)	76.39 %
Na	log10(Na+_2(mg L⁻¹)) = 1.165 - 0.001642 Discharge_2 (L sec-1)	61.40 %
K vs Disharge	log10(K+_2(mg L⁻¹)) = 0.3891 - 0.000040 Discharge_2 (L sec-1)	0.81%
SO_4^{-2}	log10(SO42-_2(mg L⁻¹)) = 0.7702 - 0.000605 Discharge_2 (L sec-1)	59.55 %
Cl-	log10(Cl-_2(mg L⁻¹)) = 1.296 - 0.001675 Discharge_2 (L sec-1)	59.01 %
TP	log10(TP_2(µg L⁻¹)) = 1.449 + 0.002231 Discharge_2 (L sec-1)	49.92 %

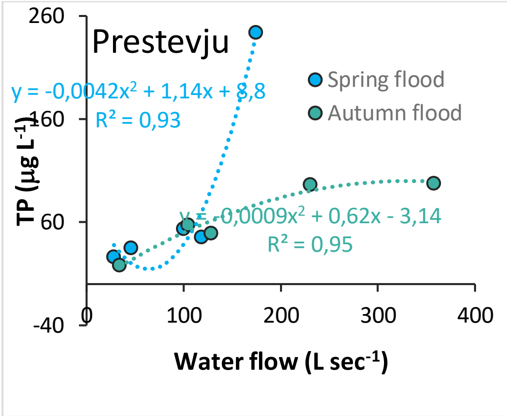
Dis. P	log10(Dis.P(μg L^{-1})) = 1.330 + 0.002053 Discharge (L sec-1)	53.04 %
Part. P	log10(Part. P(μg L^{-1})) = 0.6257 + 0.002330 Discharge (L sec-1)	10.96 %
TN	log10(Tot N(μg L^{-1})) = 3.639 - 0.000174 Discharge (L sec-1)	0.64%
Dis.N	log10(Dis. N(μg L^{-1})) = 3.485 + 0.000124 Discharge (L sec-1)	0.85%
Part. N	log10(Part. N(μg L^{-1})) = 2.947 - 0.000839 Discharge (L sec-1)	2.60%
Org. N	log10(Org N(μg L^{-1})) = 2.406 + 0.002507 Discharge (L sec-1)	5.51%
NO3--N	log10(NO3--N_2(μg L^{-1})) = 3.498 - 0.000098 Discharge_2 (L sec-1)	0.53%
Fe	log10(Fe(μg L^{-1})) = 2.320 + 0.001869 Discharge (L sec-1)	56.18 %
Mn	log10(Mn(μg L^{-1})) = - 0.1909 + 0.004217 Discharge (L sec-1)	12.03 %
Zn	log10(Zn(μg L^{-1})) = 0.8242 + 0.001620 Discharge (L sec-1)	23.30 %
Cu	log10(Cu(μg L^{-1})) = - 0.4953 - 0.002287 Discharge (L sec-1)	12.98 %

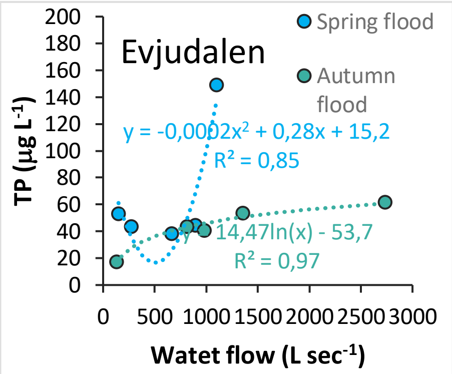
Annex 5: Simple Linear Regression Equation and R-squared value on Evjudalen stream.

	Regression Equation	R^2
pH	log10(pH_3) = 0.8605 - 0.000010 Discharge_3 (L sec-1)	27.87 %
Conductivity	log10(Cond._3) = 2,046 - 0,000125 Discharge_3 (L sec-1)	46.59 %
Turbidity	log10(Turbidity_3) = 1,148 + 0,000278 Discharge_3 (L sec-1)	25.98 %
TSS	log10(TSS_3) = 0,5708 + 0,000397 Discharge_3 (L sec-1)	35.24 %
Colour	log10(Colour_3) = 1,828 + 0,000129 Discharge_3 (L sec-1)	48.71 %
Ca2+	log10(Ca2+_3(mg L^{-1})) = 1.038 - 0.000100 Discharge_3 (L sec-1)	59.88 %
Mg2+	log10(Mg2+_3(mg L^{-1})) = 0.5494 - 0.000119 Discharge_3 (L sec-1)	69.12 %
Na+	log10(Na+_3(mg L^{-1})) = 0.8714 - 0.000203 Discharge_3 (L sec-1)	63.18 %
K+ vs Disharge	log10(K+_3(mg L^{-1})) = 0.2455 - 0.000004 Discharge_3 (L sec-1)	0.18%
SO_4-^{2}	log10(SO42-_3(mg L^{-1})) = 0.7113 - 0.000109 Discharge_3 (L sec-1)	69.18 %
Cl-	log10(Cl-_3(mg L^{-1})) = 0.9839 - 0.000192 Discharge_3 (L sec-1)	60.63 %
TP	log10(TP_3(µg L^{-1})) = 1.561 + 0.000129 Discharge_3 (L sec-1)	18.27 %
Dis. P	log10(Dis.P(µg L^{-1})) = 1.435 + 0.000124 Discharge (L sec-1)	22.84 %
Part. P	log10(Part. P(µg L^{-1})) = 0.6759 + 0.000220 Discharge (L sec-1)	10.12 %
TN	log10(Tot N(µg L^{-1})) = 3.486 - 0.000008 Discharge (L sec-1)	0.08%
Dis.N	log10(Dis. N(µg L^{-1})) = 3.355 + 0.000010 Discharge (L sec-1)	0.22%
Part. N	log10(Part. N(µg L^{-1})) = 2.723 + 0.000011 Discharge (L sec-1)	0.02%
Org. N	log10(Org N(µg L^{-1})) = 2.591 + 0.000235 Discharge (L sec-1)	9.25%
NO3--N	log10(NO3--N_3(µg L^{-1})) = 3.370 - 0.000039 Discharge_3 (L sec-1)	2.91%
Fe	log10(Fe(µg L^{-1})) = 2.402 + 0.000176 Discharge (L sec-1)	28.38 %
Mn	log10(Mn(µg L^{-1})) = - 0.5693 + 0.001015 Discharge (L sec-1)	37.84 %
Zn	log10(Zn(µg L^{-1})) = 0.7774 + 0.000089 Discharge (L sec-1)	0.98%
Cu	log10(Cu(µg L^{-1})) = - 0.5817 - 0.000262 Discharge (L sec-1)	12.25 %

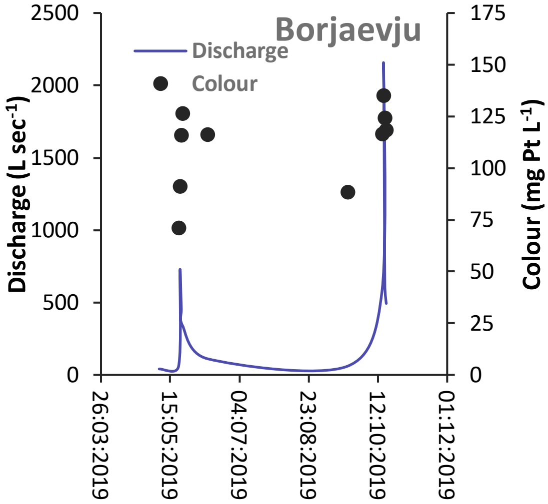
Annex 6: Relationship of discharge and Tot- P

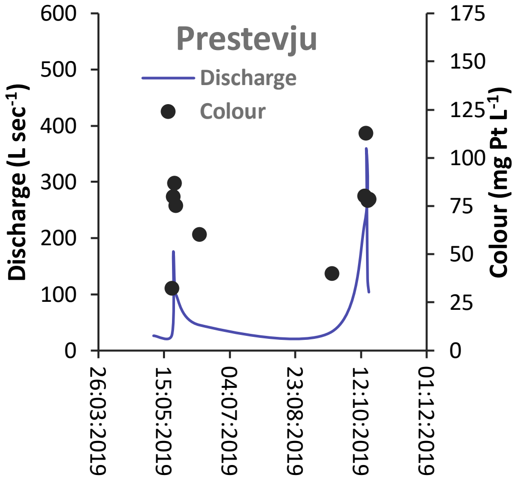


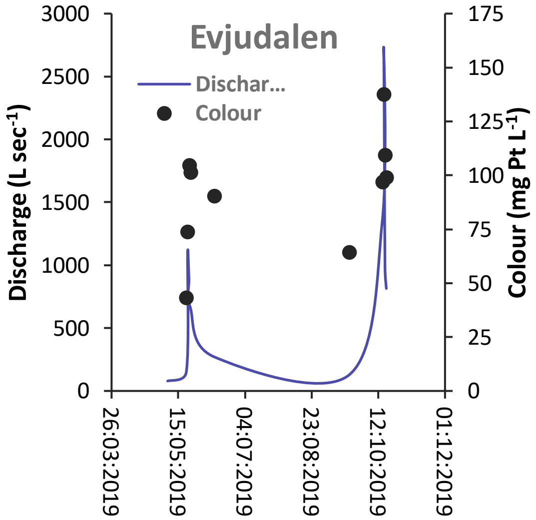




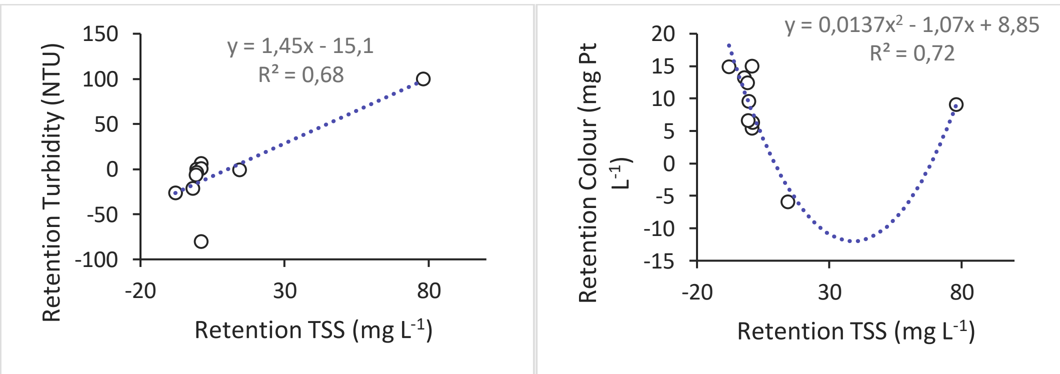
Annex 7: Distribution of discharge and colour through the sampling period

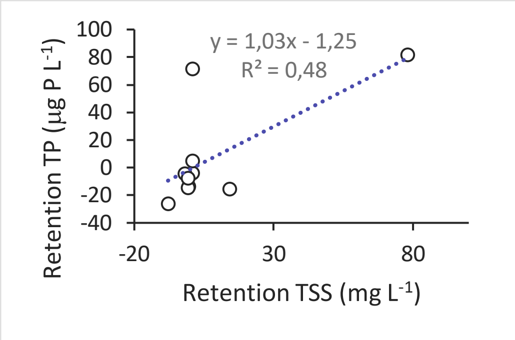


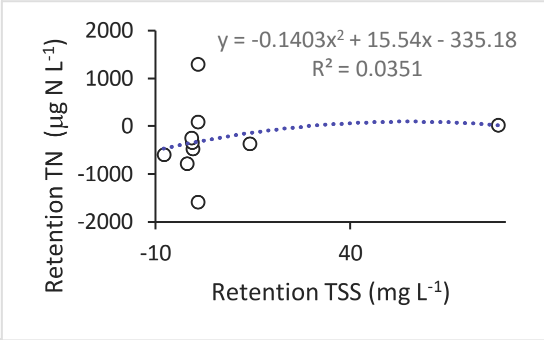


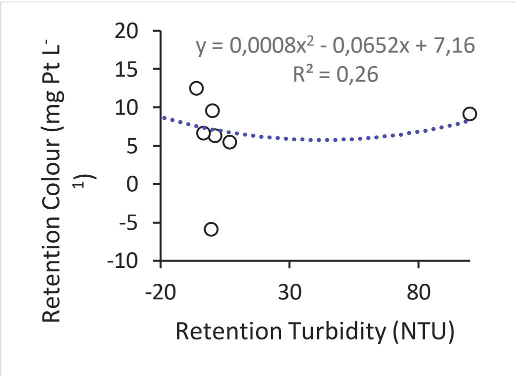


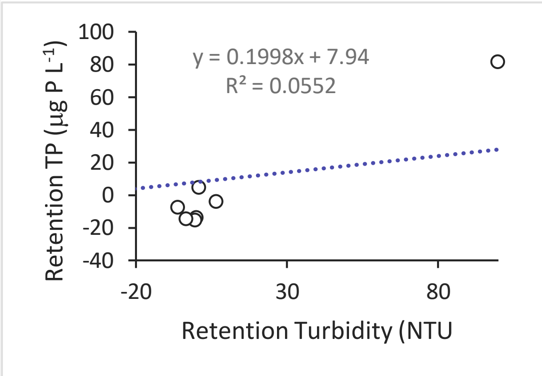
Annex 8: Relationship of retention of parameters with TSS and turbidity retained

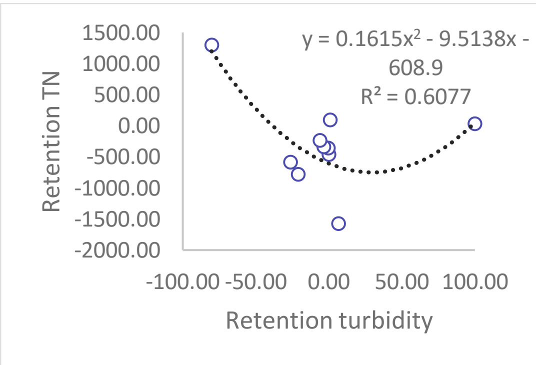



Retention TP (µg P L-1)
Retention TSS (mg L-1)
y = 1,03x - 1,25
R² = 0,48
100
80
60
40
20
0
-20
-40
-20
30
80


Retention TN (µg N L-1)
Retention TSS (mg L-1)
y = -0.1403x² + 15.54x - 335.18
R² = 0.0351
2000
1000
0
-1000
-2000
-10
40


Retention Colour (mg Pt L-1)
Retention Turbidity (NTU)
y = 0,0008x² - 0,0652x + 7,16
R² = 0,26
20
15
10
5
0
-5
-10
-20
30
80


Retention TP (µg P L-1)
Retention Turbidity (NTU
y = 0.1998x + 7.94
R² = 0.0552
100
80
60
40
20
0
-20
-40
-20
30
80


Retention TN
Retention turbidity
y = 0.1615x² - 9.5138x - 608.9
R² = 0.6077
1500.00
1000.00
500.00
0.00
-500.00
-1000.00
-1500.00
-2000.00
-100.00 -50.00 0.00 50.00 100.00