Bidang Unggulan : Pengelolaan DAS
Kode/Nama Rumpun Ilmu : Ilmu Tanah

LAPORAN AKHIR

PENELITIAN UNGGULAN PERGURUAN TINGGI

TAHUN KE-2

JUDUL PENELITIAN

PENGELOLAAN TANAH DAN AIR DI PERKEBUNAN KELAPA SAWIT UNTUK PERBAIKAN KUALITAS AIR DAS JALEMU DI KALIMANTAN TENGAH

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UNIVERSITAS PALANGKA RAYA
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RINGKASAN

Penelitian ini dilakukan pada DAS Jalemu, dan pada tahun pertama dilakukan pendataan pada kondisi sekarang tanpa memberikan perlakuan pada teknik konservasi tanah sedangkan pada tahun kedua sudah menerapkan teknik konservasi tanah dengan menggunakan rorak. Pengukuran erosi dan aliran pada setiap kejadian hujan, dilakukan pada petak erosi yang dibuat pada kawasan sawit berumur 3 tahun, 5 tahun dan kawasan hutan untuk tahun pertama dan penekanan pada kawasan sawit dengan teknik konservasi pada tahun kedua. Selain itu dilakukan pengukuran tinggi muka air dengan setting setiap 1 jam dilakukan dengan waterlogger pada DAS Jalemu, khususnya subDAS Batang Jalemu dan SubDAS Jalemu Haluli dan juga dilakukan sampling air secara rutin. Sampel terhadap air dan sedimen dari plot dianalisis dan DAS Jalemu dilaksanakan pada Laboratorium Analitik Universitas Palangka Raya. Untuk membandingkan kelembaban tanah pada kawasan hutan dan kawasan kebun sawit dilakukan pengukuran kelembaban tanah dengan sensor DL6 dan dilakukan sampling untuk kalibrasi. Hasil penelitian menunjukkan bahwa erosi dan aliran permukaan pada perkebunan kelapa sawit untuk umur 3 dan 5 tahun lebih besar daripada kawasan hutan sedangkan kelembanan tanah pada kawasan sawit sangat fluktuatif dan sangat tergantung pada curah hujan. Penelitian tahun kedua masih terus dilanjutkan hingga berakhir musim penghujan pada tahun 2019 dengan beberapa hal berikut yaitu melanjutkan pengukuran erosi dan aliran permukaan dalam plot erosi, sampling tanah untuk kalibrasi kelembaban tanah, sampling air dari DAS Jalemu, unduh data dari logger di DAS Jalemu dan CH, melakukan analisis laboratorium untuk tanah dan air baik dari plot erosi, DAS sebagai lanjutan analisis sebelumnya.

Dari hasil kegiatan penelitian ini dihasilkan satu tulisan yang sudah diterima pada Jurnal Tanah Tropika Universitas Lapamoung dan diterbitkan pada Januari 2019, selain juga dipublikasi dalam Prosiding berindkes, IOP Publishing setelah mengikuti Seminar Internasional (ICSARD) di Universitas Jendral Soedirman, Purwokerto. Tahun 2019 diharapkan masih ada publikasi yang diterbitkan dari hasil penelitian ini. Tiga orang mahasiswa S1 juga terlibat dalam kegiatan penelitian ini yang memberi nilai tambah bagi kegiatan penelitian tang didanai pihak Kemenristekdikti.

PRAKATA

Laporan akhir ini menyajikan hasil yang telah diperoleh hingga bulan Nopember 2018, dan penelitian akan dilanjutkan hingga bulan April 2019. Penelitian di lapangan untuk tahun 2018 baru bisa dilakukan secara fisik pada bulan September 2018 setelah dimulainya musim hujan. Dari penelitian 2 tahun, sebagian hasil penelitian ini telah dipresentasikan pada Seminar dalam rangka Seminar dan Rapat Tahunan Dekan Pertanian (Semirata) Wilayah Barat yang dilaksanakan di Universitas Bangka Belitung pada Tahun 2017, sedangkan pada Tahun ini dipresentasikan pada Seminar Internasional (ICSARD) di Purwokerto, Seminar Nasional di UVN Yogyakarta. Serta direncanakan dalam forum pekan ilmiah di lingkungan Universitas Palangka Raya.

Disadari bahwa terdapat beberapa kendala dalam pelaksanaan lapangan untuk kegiatan penelitian ini, naum hasil yang dapat diperoleh sudah mengarah pada apa yang diharapkan dari penelitian ini paling tidak untuk penelitian tahun pertama dan kedua.

Penulis

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BAB 1. PENDAHULUAN

Produksi kelapa sawit (*Elaeis guineensis*) telah berkembang pesat di daerah tropis selama dekade terakhir. Sebagai terbesar di dunia produsen minyak sawit sejak tahun 2007, pemerintah Indonesia berencana untuk meningkatkan produksi hingga 40 juta ton minyak mentah kelapa pada tahun 2020, terutama di Sumatera, Kalimantan, dan Barat Papua (IMA 2010). Provinsi Riau di Sumatera Tengah adalah produsen terbesar minyak sawit di Indonesia, terhitung sekitar 24% dari total produksi nasional. Dari tahun 2004 sampai 2009, daerah kelapa sawit di Provinsi Riau meningkat sebesar 21% (IMA 2010; Susanti dan Burgers 2012), dan dalam peprkembangannya wilayah Kalimantan Tengah juga meningkat luasan budidaya dan produksi sawitnya. Perkembangan luas perkebunan sawit secara khusus di Kalimantan Tengah cukup besar, demikian pula peningkatan produksinya meningkat sangat pesat. Kelapa sawit salah satu industri yang menjadi tulang punggung perekonomian dan juga memberi kontribusi terbesar terhadap ekspor nonmigas di Indonesia. Ekspansi yang cepat seperti yang industri kelapa sawit menunjukkan bahwa penggunaan lahan yang luar biasa perubahan sedang berlangsung di Indonesia, yang menimbulkan kepedulian terhadap lingkungan dan kesehatan manusia.

RSPO telah membentuk aturan prinsip-prinsip dan kriteria pengelolaan perkebunan kelapa sawit dan pabrik. Sebagai dibahas oleh Tuhan dan Clay (2006), sebagian besar kegiatan yang berhubungan dengan pengembangan perkebunan kelapa sawit dan eksploitasi (misalnya, hutan kliring, pembangunan jalan dan jaringan drainase, agrokimia penggunaan, rilis air limbah) menghadirkan risiko ke permukaan lahan dan kualitas air tanah (ECD 2000; Goh et al 2003.). Kondisi hidrologi dan ekosistem perairan dekat dengan perkebunan sangat di risiko penurunan kualitas air karena tingkat yang relatif tinggi, pupuk diterapkan di perkebunan (Sheil et al. 2009). Air limpasan dan drainase dari baru didirikan (muda) sawit perkebunan dikendalikan oleh tanaman penutup legume ditanam oleh pekebun. Namun, understory ini semakin menghilang sebagai kanopi menutup, meninggalkan tanah dengan sedikit tutupan vegetasi untuk mempertahankan kelebihan air dan sedimen yang kaya nutrisi. Sebagai tambahan, kematian dan selanjutnya dekomposisi penutup legume tanaman di bawah kanopi padat telapak tangan dewasa melepaskan nitrogen yang sebelumnya tetap melalui fiksasi nitrogen biologis (Breure 2003; Campiglia et al 2010;.. Goh et al 2003). Goh dan Chew (1995) menegaskan bahwa kerugian nitrat pencucian dari tanaman kacangan dipengaruhi oleh tekstur tanah dan lebih besar kerugian tercatat di tanah berpasir.

Berbagai isu lingkungan terus terjadi terkait dengan perkembangan perkebunan kelapa sawit ini, salah satunya adalah terkait masalah kondisi air di kawasan. Terkait dengan pemburukan krisis air di berbagai daerah, sebagian kalangan menuding bahwa perusahaan berbasis kelapa sawit banyak memiliki andil dalam pemborosan debit air untuk menghidupi perkebunannya.

Isu mengenai terganggunya tata air kawasan yang disebabkan perkembangan kelapa sawit telah merebak sebagai isu lingkungan. Pertanaman kelapa sawit dinilai sebagai penyebab berkurangnya ketersediaan air tanah dan dapat menimbulkan dampak menurunnya muka air tanah. Berbagai tantangan tersebut di atas dikhawatirkan akan mempengaruhi tingkat produktivitas dan volume ekspor minyak kelapa sawit dan produksi turunannya. Selain itu juga akan selalu digunakan sebagai isu yang semakin menyudutkan perkebunan sawit dan produk turunannya.

Sebuah kerugian besar air dari tanah akan menyebabkan penurunan kedalaman muka air. Faktor utama yang menentukan kedalaman muka air yang infiltrasi, curah hujan dan mekanisme perkolasi sebagai sumber resapan dalam suatu sistem dan evapotranspirasi oleh upflux sebagai debit yang menyebabkan hilangnya air dari sistem.

Perumusan Masalah

Isu tentang pertanaman kelapa sawit yang rakus air menjadi salah satu isu lingkungan sebagai dampak perkebunan kelapa swait di dalam suatu kawasan, namun belum ada data yang mendukung tudingan tersebut. Bersamaan dengan erosi dan aliran permukaan yang terjadi dari perkebunan sawit, ada indikasi akan menyebabkan proses perubahan kualitas air pada ekosistem perairan di sekitar lokasi perkebunan sawit yang terkait dengan unsur hara baik yang terlaur maupun terangkut dalam sedimen. Dugaan sementara bahwa kehilangan air dan terganggunya sistem tata air pada suatu kawasan lebih disebabkan oleh hilangnya fungsi penyimpanan air pada lahan perkebunan dan bukan oleh konsumsi tanaman sawit.

Oleh karena itu perlu dilakukan penelitian untuk melihat neraca air pada kawasan DAS yang mencakup kawasan perkebunan kelapa sawit, dengan meneliti setiap komponen dalam neraca air. Dari hasil penelitian ini akan terjawab porsi mana menyebabkan kerusakan kekseimbangan air dalam suatu kawasan DAS.

BAB 2. TINJAUAN PUSTAKA

Produksi air (*water yield*) diubah melalui perubahan transpirasi, intersepsi, dan penguapan, yang semuanya cenderung meningkat ketika terjadi perubahan tutupan lahan. Laju transpirasi dipengaruhi oleh perubahan karakteristik perakaran, luas daun, respon stomata, albedo permukaan tanaman, dan turbulensi (Brooks et al, 1997;. Hoffmann & Jackson, 2000;. Jackson et al, 2001; Vertessy, 2001). Meskipun transpirasi secara tradisional dianggap sebagai komponen yang lebih penting dari evapotranspirasi hutan (ET), intersepsi dan penguapan dan dari kanopi juga dapat meningkatkan secara substansial terutama dengan konifers (Pearce & Rowe, 1979; Cannell, 1999). Jumlah dari perubahan evaporasi dan transpirasi di daerah tangkapan perkebunan menyebabkan peningkatan ET (Holmes & Sinclair, 1986); misalnya, ET dari tangkapan ditanami kayu putih bisa 40-250mm lebih tinggi dari dari tangkapan padang rumput (Zhang et al., 1999). Meskipun pengakuan laju ET yang lebih tinggi di perkebunan, kemungkinan bahwa ini akan mengurangi produksi air tidak selalu diakui (Vertessy & Bessard, 1999), khususnya dalam konteks program penghijauan untuk penyerapan karbon.

Studi tentang efek perubahan vegetasi pada produksi air fokus terutama pada pengurangan vegetasi berkayu (Bosch & Hewlett, 1982; Scott et al, 2000). Studi deforestasi dibedakan oleh faktor-faktor seperti gangguan tanah dan pengendapan slash dan sampah, yang dapat mempengaruhi pola aliran sungai (Vertessy, 1999). Meskipun efek dari usia perkebunan dan panjang rotasi yang penting untuk memprediksi konsekuensi dari aforestasi pada produksi air, efek ini kurang dalam kebanyakan studi (Best et al., 2003). Pemahaman yang lebih baik tentang hubungan usia tanaman dan limpasan setelah penghijauan akan memungkinkan untuk membuat prediksi menggunakan skenario rotasi lebih realistis - di mana proporsi lanskap dalam tahap pertumbuhan awal, dan penuaan penuh dicegah dengan panen. Perubahan aliran rendah mungkin bahkan lebih penting daripada perubahan dalam aliran tahunan, sebagai musim kemarau adalah ketika berkurangnya pasokan air akan memiliki efek paling parah bagi pengguna, terutama di daerah kering dan semi kering (Smith & Scott, 1992; Scott & Smith, 1997;. Sharda et al, 1998; Robinson et al, 2003).

Beberapa penelitian yang telah dilakukan dan terkait dengan penelitian ini :

1. Pasaribu, Mulyadi dan Tarumun (2012) telah mendapatkan data tentang intersepsi pada tegakan kelapa sawit (sebesar 21.23 % dari curah hujan), evapotranspirasi berkisar 68.23-125.63 mm/bulan, dengan rata-rata sebesar 92.05 mm/bulan atau setara dengan 1.104,5 mm/tahun. Kebutuhan air tanaman kelapa sawit lebih kecil jika dibandingkan dengan kebutuhan air pada tanaman kelapa dan tanaman hutan seperti pinus, akasia, segon, karet dan jati. Kedalaman muka air tanah di area pertanaman kelapa sawit berfluktuasi yang dipengaruhi kondisi iklim, terutama curah hujan. Muka air tanah menurun pada periode musim kering dan meningkat kembali pada musim penghujan. Penurunan muka air tanah tersebut tidak bersifat permanen.
2. Jumlah air yang dibutuhkan pertumbuhan dan produksi tanaman kelapa sawit berkisar 1.700-3.000 mm per tahun dan harus merata sepanjang tahun atau tanpa dry spell yang mencolok. penelitian ini mengkaji pengaruh teknik konservasi tanah dan air berupa guludan bersaluran dan rorak dengan mulsa vertikal terhadap perubahan neraca air pada perkebunan kelapa sawit. Penelitian dilakukan pada PT Perkebunan Nusantara, Lampung dari Juni 2005 hingga Oktober 2007.
3. Kelapa sawit telah diperkirakan menggunakan air antara 1,83-4,13 mm/hari untuk pertumbuhan dan produktivitas (Harahap dan Darmosarkoro, 1999) dibandingkan dengan pohon-pohon hutan dan tanaman tahunan yang membutuhkan sekitar 5,02-6,32 mm dan 1,83-4,13 mm/hari(Schilling, 2007).

Konversi penggunaan lahan, khususnya dari hutan menjadi lahan pertanian atau padang rumput, sangat mempengaruhi fluks hara dalam DAS (Vitousek et al, 1997). Efek konversi hutan menjadi perkebunan terhadap nitrogen dan fosfor memang sepenuhnya belum dipahami. Substitusi vegetasi dengan praktik penebangan kemungkinan berdampak pada kualitas air sungai melalui hilangnya biomassa, jumlah variabel slash logging di lantai hutan, erosi tanah dan mineralisasi N yang dipercepat (Nykvist, Grip, Liang Sim, Malmers, & Khiong Wong, 1994).

Nitrat-N adalah fraksi yang dominan (> 50%) dalam kehilangan nitrogen, terutama di daerah tangkapan didominasi oleh perkebunan. Di DAS dengan vegetasi hutan, NO3 hanya memberikan kontribusi sebesar 34% dari hilangnya nitrogen dan DON adalah output utama sebebsar 55%. Hilangnya NO3 tahunan lebih rendah di daerah tangkapan air dengan hutan asli dibandingkan dengan tangkapan dengan perkebunan di mana output debit sungai melebihi masukan curah hujan. Input rata-rata total-N 2,6 kg/ha/tahun (DIN = 1,4 kg/ha/ tahun, DON = 1,2 kg/ha/tahun) dan output yang 1,7 kg/ha/tahun (DIN = 1,2 kg/ha/tahun, DON = 0,5 kg/ha/tahun). retensi tahunan nitrogen total berfluktuasi antara 61% di DAS didominasi oleh hutan 15% di daerah tangkapan didominasi oleh perkebunan *Eucalyptus* sp. retensi nitrogen positif terkait dengan cakupan hutan asli (Carlos Oyarzun, Claudia Aracena, Patricio Rutherford, Roberto Godoy dan An Deschrijver, 2007).

BAB 3. TUJUAN DAN MANFAAT PENELITIAN

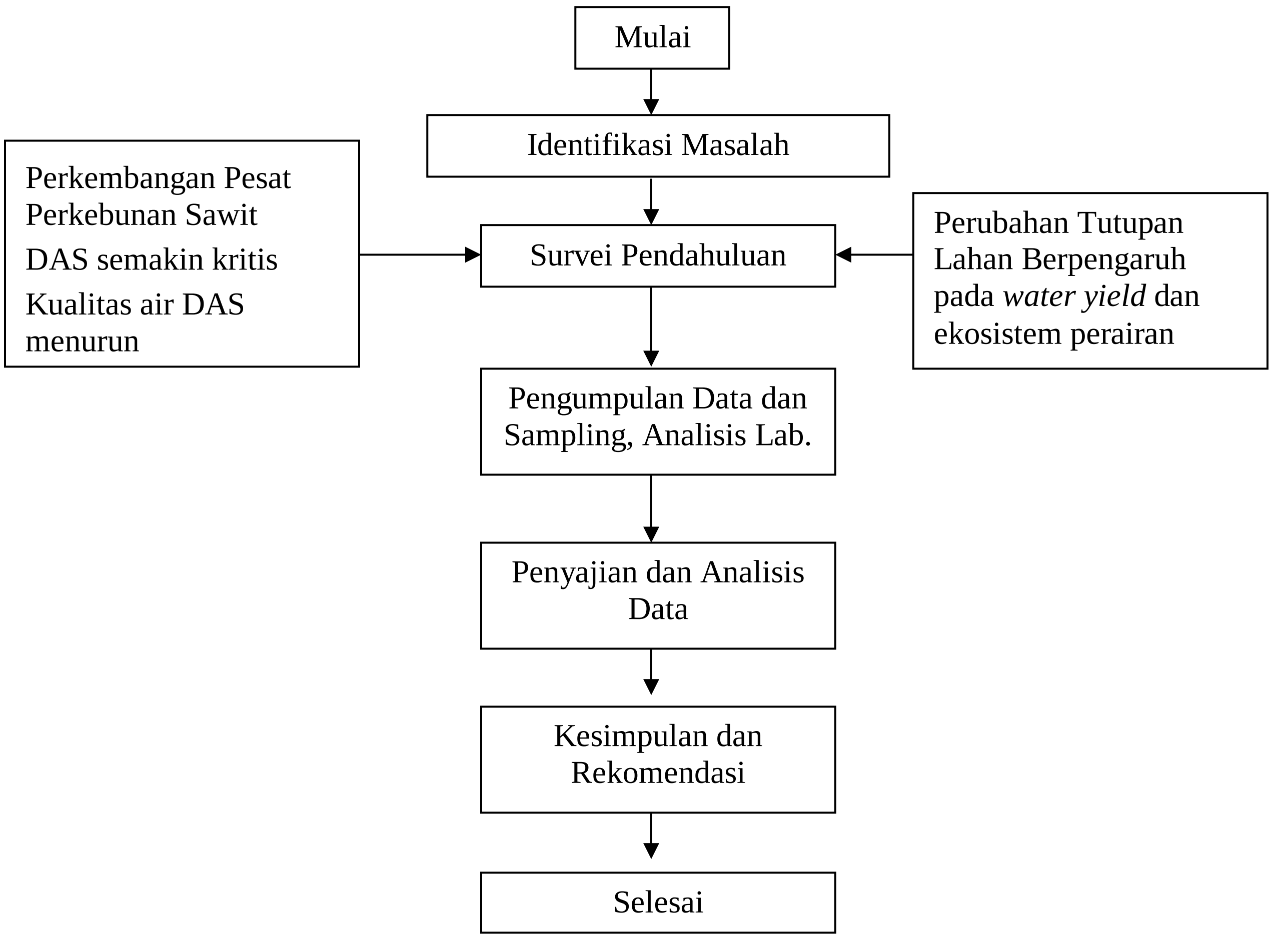
a. Tujuan

Untuk mengklarifikasi isu lingkungan terkait masalah kekurangan air dan beberapa alternatif teknik pengelolaan lahan yang memungkinkan resapan air yang baik, maka penelitian ini bertujuan untuk :

1. Menganalisis neraca air di kawasan DAS dengan dominasi perkebunan kelapa sawit, dan dampaknya terhadap lingkungan khususnya dari neraca air tanaman kelapa sawit.
2. Mengkaji dampak kegiatan perkebunan kelapa sawit pada kualitas air di ekosistem perairan terutama yang bersumber dari unsur hara yang terbawa dalam aliran permukaan dan erosi.
3. Melakukan ujicoba berbagai teknik pengelolaan air di tapak perkebunan untuk meningkatkan penyimpanan air.

BAB 4. METODE PENELITIAN

Penelitian ini dilakukan di lapangan dan di laboratorium. Kegiatan di lapangan meliputi pengambilan data karakteristik tanah, hidrologi, klimatologi. Selain itu dilakukan uji coba dan pengukuran erosi dan aliran permukaan dengan menggunakan petak ukur standar untuk erosi dan aliran permukaan. Kegiatan laboratorium berupa analisis air, tanah dan sedimen. Diagram alir penelitian disajikan pada Gambar 1.



Gambar 1. Diagram Alir Penelitian

Penelitian akan dilaksanakan pada kawasan Daerah Aliran Sungai (DAS) Jalemu yang merupakan salah satu Sub DAS Manuhing di Kecamatan Manuhing, Kabupaten Gunung Mas, Provinsi Kalimantan Tengah. DAS ini di dominasi perkebunan sawit (perusahaan maupun milik rakyat) dan pada beberapa kawasan ditemukan tutupan lahan lainya baik hutan maupun tanaman budidaya. Data harian dan bulanan curah hujan, evaporasi, cucuran tajuk (throughfall), aliran batang (stemflow), intersepsi, kelembaban tanah dan muka air tanah serta debit aliran saluran diperoleh dari peralatan-peralatan yang dipasang di microcatchment di setiap blok penelitian.

Tahap pengumpulan data tanah meliputi beberapa kegiatan pengamatan parameter tanah antara lain:

a. Data Tanah

Data tanah meliputi (sifat fisika dan kimia tanah). Sifat-sifat tersebut sebagai data spasial dan merupakan karakteristik pedon pewakil dari masing-masing satuan peta tanah (SPT). Deskripsi pedon pewakil dilakukan berdasarkan sebaran tanah melalui pengamatan minipit dan pengeboran. Pengamatan dilakukan secara toposekuen dan sekaligus mengambil contoh tanah terkait kedalaman horizon dan untuk dianalisis laboratorium mengenai proporsi pasir, liat, dan debu, sehingga dapat diperoleh informasi karakteristik tanah maupun penyebarannya secara maksimal.

Analisis tanah dilakukan pada parameter kandungan bahan organik, N, P, K, basa-basa, KTK, pH, tesktur tanah, permeabilitas. Analisis dilakukan di laboratorium Analitik Universitas Palangka Raya.

b. Data topografi

Data topografi dan batasan DAS dan sub DAS lokasi penelitian diperoleh melalui analisis DEM (*digital elevation model*) untuk kawasan penelitian.

c. Data tutupan lahan

Data tutupan lahan diperoleh dari analisis citra satelit terbaru dengan verifikasi lapangan baik menggunakan survei darat maupun dengan bantuan drone.

d. Data hidrologi

Beberapa parameter yang diukur meliputi :

1. Tinggi muka air (TMA) baik di lahan perkebunan, maupun di DAS. Pemasangan automatic water logger untuk memonitor perubahan tinggi muka air di lahan lakukan sebanyak 1 buah dan sebanyak 1 buah di badan sungai untuk memonitor tinggi muka air di sungai. Periode pengamatan perubahan TMA di lakukan setiap peride 1 (satu) jam. Download data automatic water logger dilakukan setiap 4 bulan dan salah satu dari automatic water logger (bersama

dengan satu rain gaunge) dipasangkan dengan sistem SESAME yang akan memberikan gambaran data real time kepada peneliti.

2. Rain gauge tipe tipping bucket dipasang di kawasan penelitian sebanyak 2 (dua) set dan ditempatkan sesuai dengan kondisi dan luasan di lapangan, agar diperoleh gambaran curah hujan secara baik di lokasi penelitian.
3. Pengukuran debit dilakukan pada saat air dibadan sungai tersedia dan dilakukan setiap periode 2 bulan. Titik pengukuran debit berada sama dengan titik dipasangnya automatic water logger di sungai (badan air).

Metode Analisis

Agar dapat mencapai sasaran riset dan diperoleh luaran yang sesuai dengan harapan, maka data hasil pengamatan selanjutnya dianalisis menggunakan metedo rasional, SCS, dan metode neraca air lahan. Untuk membandingkan rona awal sebelum pengembangan perkebunan kelapa sawit dan setelah dikembangkan perkebunan kelapa sawit terhadap respon hidrologi dan distribusi air yang terjadi di kawasan DAS, termasuk masing-masing tutupan terhadap kontribusi hidrologisnya dilakukan dengan pendekatan model SWAT (*Soil and Water Assessment Tools)* dengan basis data citra satelit dan hasil pengamatan lapang.

e. Data kualitas air dan sedimen

Pengambilan sampel air dilakukan setiap 2 (dua) bulan untuk analisis kandungan hara N, P dan K serta analisis kadar sedimen dilakukan pada titik pengamatan TMA di sungai. Analisis juga dilakukan untuk kandungan hara N, P dan K dalam sedimen. Perhitungan dilakukan untuk total hara N, P dan K dalam air maupun sedimen yang berada di outlet DAS yang dikaji. Hasil analisis kadar N, P dan K dalam air dan sedimen dibandingkan dengan baku mutu kualitas air. Analisis air dan sedimen dilakukan di Laboratorium Analitik Universitas Palangka Raya.

f. Plot erosi dan kehilangan hara

Untuk mengetahui besarnya erosi dan aliran permukaan serta hara yang terbawa oleh kedua proses tersebut, maka dilakukan pengukuran dengan menggunakan petak erosi standar. Pengambilan sampel sedimen dan air dilakukan setiap 2 (dua) bulan sekali atau pada saat bak penampung sudah penuh. Analisis kandungan N, P dan K dalam air dan sedimen dilakukan di Laboratorium Analitik, Universitas Palangka Raya.

BAB 5. HASIL DAN LUARAN YANG DICAPAI

a. Luaran Yang dicapai

Adapun capaian kegiatan penelitian PUPT Tahun ke-2 dari rencana atau taget sebelumnya dirangkum dalam Tabel 1.

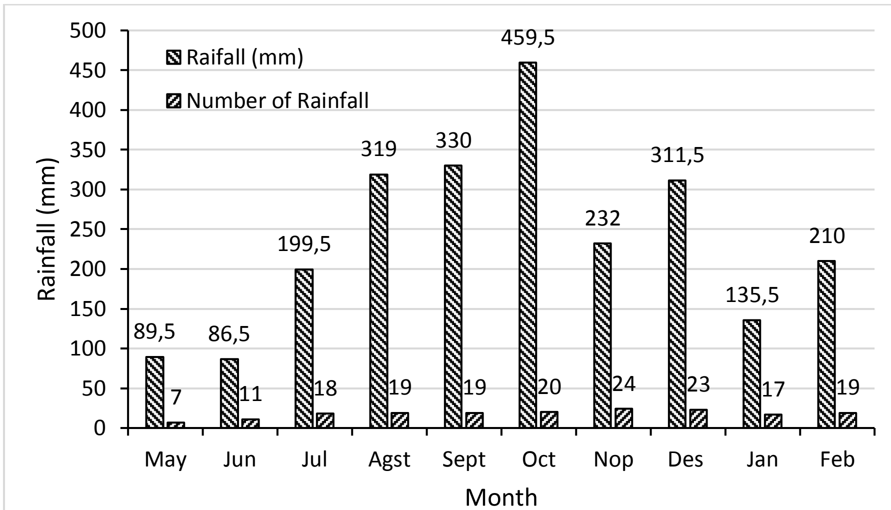
Tabel 1. Hasil dan luaran yang dicapai

No.	Jenis Luaran		Indikator Capaian	
			Tahun I	Tahun II-
1.	Publikasi ilmiah	Internasional	Draft	Draft (edit bahasa)
		Nasional Terakreditasi	Draft	Submitted ke Jurnal Tanah Tropika
2.	Pemakalah dalam temu ilmiah	Internasional	Draft	ICSARD Purwokerto
		Nasional	Semirata Faperta di Pangkal Pinang 20 Juli 2017	Pertemuan Perhimpunan Profesi dan Seminar Nasional Dies Natalis UVN Yogyakarta, 17 Nopember 2018
3.	Inivited speaker dalam temu Ilmiah	Internasional	Draft	Dilaksanakan
		Nasional	Draft	
4.	Visiting Lecturer	Internasional	Tidak ada	Kunjungan ke Universitas Nottingham, Inggris
5.	Hak Kekayaan Intelektual (HKI)	Paten	Tidak ada	Tidak ada
		Paten sederhana	Tidak ada	Tidak ada
		Hak Cipta	Tidak ada	Tidak ada
		Merek dagang	Tidak ada	Tidak ada
		Rahasia dagang	Tidak ada	Tidak ada
		Desain Produk Industri	Tidak ada	Tidak ada
		Indikasi Geografis	Tidak ada	Tidak ada
		Perlindungan Varietas Tanaman	Tidak ada	Tidak ada
		Perlindungan Topografi Sirkuit Terpadu	Tidak ada	Tidak ada
6.	Teknologi Tepat Guna		Draft	Draft
7.	Model/Purwarupa/Desain/Karya seni/ Rekayasa Sosial		Tidak ada	Tidak ada
8.	Buku Ajar (ISBN)		Draft	Editing
9.	Tingkat Kesiapan Teknologi (TKT)		Skala 1	Skala 1

b. Hasil Penelitian

1. Curah Hujan

Data curah hujan yang direkam dengan menggunakan ombrometer tipe tipping bucket selama penelitian dan hasil pengolahan dalam curah hujan bulanan disajikan pada Gambar 2. Hasil pengamatan menunjukkan adanya 117 hari hujan yang teramati pada periode Mei 2017 sampai Februari 2018.

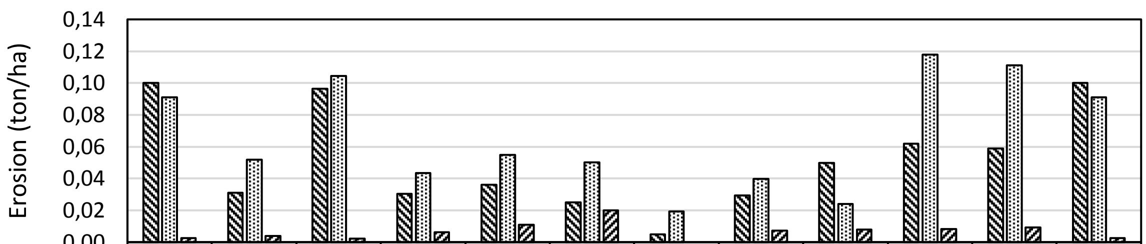


Gambar 2. Jumlah dan hari hujan di lokasi penelitian selama periode penelitian.

Gambar 2 menunjukkan adanya pola penurunan curah hujan pada masing-masing perlakuan pada periode musim kemarau, yaitu pada bulan Mei dan Juni. Curah hujan terbesar selama periode penelitian terjadi pada bulan Oktober 2017 yaitu sebesar 459,5 mm sedangkan terkecil terjadi pada Bulan Juni 2017 sebesar 86,5mm. Untuk jumlah hari hujan terbanyak berlangsung pada Bulan Nopember yakni sebanyak 24 hari sedangkan jumlah hari hujan terendah ada pada Bulan Mei yakni sebanyak 7 hari. Hujan merupakan salah satu faktor penting yang mempengaruhi besarnya nilai erosi dan aliran permukaan dan merupakan awal penyebab terjadinya erosi dengan adanya energi yang menimbulkan efek terhadap dispersi tanah. Penghancuran butir tanah tersebut serta daya rusak oleh aliran permukaan yang ditimbulkan hujan sangat besar pengaruhnya terhadap erosi. Hujan merupakan bagian dari faktor iklim yang berperan dalam mengendalikan aliran permukaan dan erosi. Beberapa karakteristik hujan yang berpengaruh terhadap besarnya aliran permukaan adalah tipe hujan, intensitas hujan, lama hujan, distibusi hujan, dan arah hujan (Haridjaja dkk, 1990). Pengaruh intensitas hujan mempunyai hubungan yang berbanding lurus terhadap jumlah dan laju aliran permukaan. Pada umumnya terjadi kecenderungan peningkatan jumlah aliran permukaan dengan meningkatnya intensitas hujan, tetapi hal ini juga tergantung dengan kapasitas infiltrasi tanah. Jika intensitas hujan melebihi kapasitas infiltrasi tanah, maka akan terjadi peningkatan jumlah aliran permukaan sejalan dengan peningkatan intensitas hujannya. Faktor lama hujan juga berpengaruh terhadap besarnya jumlah aliran permukaan (Sukartaatmadja, 1998). Semakin lama hujan turun, maka semakin besar aliran permukaan yang terjadi, walaupun hal ini tergantung pada intensitas hujan dan besarnya jumlah hujan.

2. Erosi

Hasil perhitungan erosi yang terjadi pada untuk beberapa kejadian hujan baik untuk kawasan hutan serta pada kebun sawit berumur 3 dan 5 tahun disajikan pada Gambar 3.



	12-May	17-May	22-May	1-Jun	12-Jun	20-Jun	9-Jul	6-Sep	30-Sep	11-Oct	31-Oct	Avg
OP 3 Yrs	0,10	0,03	0,10	0,03	0,04	0,03	0,00	0,03	0,05	0,06	0,06	0,10
OP 5 Yrs	0,09	0,05	0,10	0,04	0,06	0,05	0,02	0,04	0,02	0,12	0,11	0,09
Forest	0,00	0,00	0,00	0,01	0,01	0,02	0,00	0,01	0,01	0,01	0,01	0,00

Date

Gambar 3. Erosi yang terjadi pada kawasan hutan serta perkebunan kelapa sawit berumur 3 tahun dan 5 tahun

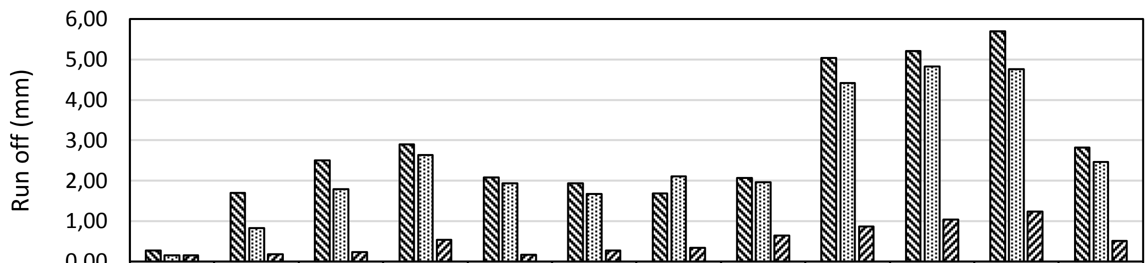
Dari Gambar 3 tampak bahwa tingkat erosi pada perkebunan kelapa sawit berumur 3 tahun lebih besar dari sawit 5 tahun dan kemudian diikuti oleh nilai erosi dari kawasan hutan dan hal tersebut terjadi pada sebagian besar kejadian hujan. Rata-rata erosi yang terjadi pada pada perkebunan kelapa sawit sawit berumur 3 tahun sebesar 0,10 ton/ha, 5 (lima) tahun adalah 0,09 ton/ha, dan pada kawasan hutan sebesar 0,002 ton/ha. Besar kecilnya nilai erosi pada berbagai kejadian hujan tersebut sangat terkait dengan curah hujan yang terjadi pada tanggal tersebut, baik jumlah hujan maupun intensitas hujan. Salah satu faktor yang berpengaruh terhadap besarnya erosi adalah tutupan tajuk tanaman. Pada kawasan perkebunan kelapa sawit berumur 3 tahun dan 5 tahun, tajuk vegetasi lebih kecil dibandingkan dengan tutupan pada kawasn hutan. Sebagaimana banyak pustaka menyebutkan bahwa besarnya erosi dipengaruhi oleh vegetasi penutup. Tajuk pohon pada kawasan hutan memiliki kesempatan untuk menangkap (*intersepsi*) hujan yang jatuh dan mengurangi efek pukulan butir hujan terhadap tanah yang bisa menimbulkan efek dispersi butiran partikel tanah. Sementara sebaliknya pada kawasan perkebunan kelapa sawit persentasi tutupan tajuk lebih rendah memungkinkan lolosan butir hujan lebih banyak.

Tanaman yang mempunyai akar serabut seperti tanaman kelapa sawit, lebih efektif dalam mengendalikan proses terjadinya erosi, hal ini disebabkan karena benang–benang halus pada akar serabut mampu mengikat butir–butir tanah menjadi agregat tanah yang mantap. Fase pertumbuhan (umur) tanaman juga mempunyai pengaruh yang berbeda terhadap proses pengendalian erosi. Pada awal pertumbuhan tanaman penutupan tajuk masih relatif terbuka, sehingga menyebabkan air hujan yang jatuh langsung menuju permukaan tanah. Hal ini dapat mempercepat terjadinya aliran permukaan karena kesempatan air untuk terinfiltrasi ke dalam tanah rendah. Tinggi tanaman juga berperan dalam peningkatan efektifitas tanaman penutup dalam mengurangi erosi. Semakin rendah tajuk dan semakin rapat tajuk tanaman maka semakin kecil energi hujan yang sampai di permukaan tanah (Arsyad, 2000). Rahim (2003) menjelaskan bahwa vegetasi mampu mempengaruhi erosi karena adanya : (1) intersepsi hujan oleh tajuk dan absorpsi energi air hujan sehingga memperkecil erosivitasnya, (2) pengaruh terhadap limpasan permukaan, (3) peningkatan aktivitas biologi tanah, dan (4) peningkatan kecepatan kehilangan air melalui transpirasi. Pengaruh faktor vegetasi terhadap besarnya erosi yang terjadi dapat dilihat tingkat penutupan tajuk tanaman dan vegetasi penutup tanah yang terdapat pada masing- masing plot hutan dan tanaman kelapa sawit. Tanaman kelapa sawit yang berada pada daerah penelitian merupakan tanaman yang telah berumur 5-6 tahun dengan tingkat penutupan tajuk tanaman yang relatif rapat dibanding tanaman sawit yang lebih muda, namun masih lebih terbuka dibandingkan hutan. Hal ini dapat dilihat dari jarak antar tajuk dari satu tanaman dengan tanaman yang lain cukup dekat. Tingkat penutupan tajuk tanaman yang relatif rapat menyebabkan hujan yang jatuh akan lebih banyak tertahan oleh tajuk tanaman. Selain tertahan oleh tajuk tanaman hujan yang jatuh juga dapat mengalir melalui aliran batang yang selanjutnya akan diteruskan ke permukaan tanah dengan kekuatan yang relatif kecil. Berkurangnya energi butir hujan yang sampai ke permukaan tanah akan berakibat pada berkurangnya kemampuan butir hujan dalam mendispersi tanah sehingga dapat menurunkan besarnya erosi yang terjadi. Pada kawasan hutan, adanya stratifikasi tajuk juga mempengaruhi menurunnya efek pukulan butir hujan dan aliran permukaan, yang pada akhirnya dapat menurunkan erosi.

Selain penutupan tajuk tanaman adanya vegetasi penutup tanah juga berpengaruh terhadap besarnya erosi yang terjadi. Pada kawasan hutan, vegetasi penutup tanah pada daerah penelitian didominasi oleh tanaman rendah dan stratifikasi pohon yang lebih baik. Vegetasi penutup tersebut menyebabkan berkurangnya dispersi air hujan dan mengurangi jumlah serta kecepatan aliran permukaan sehingga dapat mengurangi erosi (Arsyad, 2000).

3. Aliran Permukaan

Hasil perhitungan aliran permukaan yang terjadi pada beberapa kejadian hujan baik untuk kawasan hutan dan pada kebun sawit berumur 3 dan 5 tahun disajikan pada Gambar 4.



	12-May	17-May	22-May	1-Jun	12-Jun	20-Jun	9-Jul	6-Sep	30-Sep	11-Oct	31-Oct	Avg
OP 3 Yrs	0,27	1,70	2,50	2,90	2,09	1,93	1,69	2,07	5,03	5,21	5,69	2,83
OP 5 Yrs	0,16	0,82	1,79	2,63	1,94	1,67	2,10	1,97	4,41	4,83	4,77	2,46
Forest	0,15	0,18	0,23	0,54	0,17	0,28	0,34	0,64	0,86	1,04	1,23	0,52

Date

Gambar 4. Aliran permukaan yang terjadi pada kawasan hutan serta perkebunan kelapa sawit berumur 3 dan 5 tahun

Dari Gambar 4 tampak bahwa aliran permukaan pada perkebunan kelapa sawit berumur 3 tahun lebih besar dari pada sawit berumur 5 tahun, dan diikuti dari kawasan hutan dan hal tersebut terjadi pada sebagian besar kejadian hujan. Rata-rata aliran permukaan yang terjadi pada pada perkebunan kelapa sawit sawit berumur 3 tahun sebesar 2,83 mm diikuti sawit berumur 5 tahun sebesar 2,46 mm dan pada kawasn hutan sebesar 0,52 mm. Curah hujan merupakan penyebab terjadinya aliran permukaan, apabila hujan yang jatuh pada suatu areal telah melebihi kapasitas infiltrasi tanah maka kelebihan air hujan tersebut akan berubah menjadi aliran air yang mengalir di permukaan (aliran permukaan). Walaupun pada umumnya terjadi peningkatan curah hujan yang diikuti oleh peningkatan aliran permukaan, akan tetapi terdapat beberapa faktor lain yang juga berpengaruh sehingga besarnya curah hujan tidak bisa dijadikan sebagai parameter utama dalam menentukan besarnya aliran permukaan. Faktor lama hujan dan keadaan air tanah awal juga berpengaruh terhadap besarnya aliran permukaan yang dihasilkan. Apabila keadaan air tanah (kadar air) awal rendah, maka curah hujan yang turun akan lebih banyak terinfiltrasi ke dalam tanah sampai kapasitas lapang terpenuhi, sehingga jumlah air yang keluar sebagai aliran permukaan menjadi lebih kecil. Hal ini dapat terjadi pada kejadian hujan dengan jumlah curah hujan rendah, dimana curah hujan yang jatuh kurang dari kapasitas infiltrasi tanah. Sebaliknya apabila curah hujan melebihi kapasitas infiltrasi tanah maka tanah akan lebih cepat mencapai keadaan jenuh. Hal ini mengakibatkan hanya sebagian kecil dari hujan yang jatuh yang akan terinfiltrasi ke dalam tanah dan selebihnya akan mengisi cekungan-cekungan di permukaan dan pada akhirnya akan meningkatkan jumlah aliran permukaan.

4. Unsur Hara yang hilang dalam erosi dan aliran permukaan

Rata-rata hasil analisis laboratorium untuk unsur hara N, P dan K yang hilang dalam erosi dan aliran permukaan disajikan masing-masing pada Tabel 2 dan 3. Sedangkan perhitungan jumlah hara N, P dan K yang terbawa dalam erosi dan aliran permukaan pada setiap plot perlakuan masing-masing disajikan pada Gambar 5-10.

Tabel 2. Rata-rata hasil analisis laboratorium untuk hara N, P dan K dalam tanah tererosi

	Tutupan Lahan	N-Total (%)	P total (ppm)	K Total (me/100 g)
Minimum	Sawit 3 tahun	0,16	10,09	0,03
	Sawit 5 tahun	0,15	5,45	0,05
	Hutan	0,17	16,08	0,08
Maksimum	Sawit 3 tahun	0,23	29,39	0,19
	Sawit 5 tahun	0,30	18,14	0,14
	Hutan	0,33	171,72	0,90
Rata-rata	Sawit 3 tahun	0,19	19,63	0,09
	Sawit 5 tahun	0,21	12,34	0,08
	Hutan	0,22	60,01	0,33

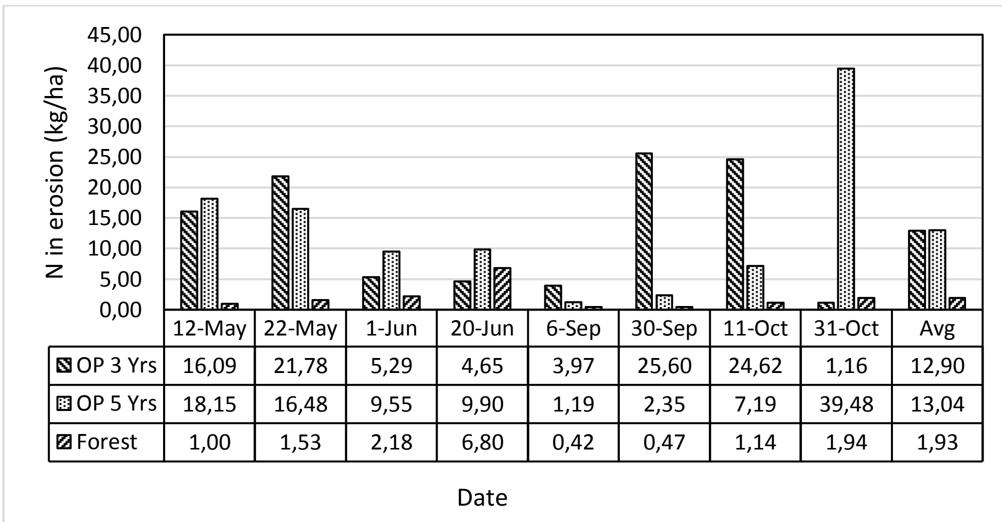
Berdasarkan pada Tabel 2, tampak bahwa kandungan unsur hara N total dalam sedimen tererosi pada plot tanaman sawit berumur 3 tahun berkisar antara 0,16-0,23% dan rata-rata 0,19% serta untuk 5 tahun berkisar antara 0,15-0,30% dengan rata-rata sebesar 0,21%, sedangkan P-total berkisar antara 10,09-29,39 ppm dan rata-rata 19,63ppm (3 tahun); 5,45-18,14 ppm dengan rata-rata sebesar 12,34 ppm (sawit 5 tahun) serta 16,08-171,72 ppm dan rata-rata 60,01 ppm P (hutan). Untuk total kandungan hara K dalam sedimen tererosi sebesar 0,03-0,19 me/100gr dan rata-rata 0,09 me/100gr tanah (sawit 3 tahun); 0,05-0,14 me/100 gr tanah dengan rata-rata sebesar 0,08 me/100gr tanah (sawit 5 tahun); 0,08-0,90 me/100 gr tanah dan rata-rata 0,33 me/100 gr tanah (hutan). Dengan demikian secara keseluruhan kandungan unsur hara N, P dan K yang terbawa partikel tanah dari kawasan hutan lebih tinggi dibandingkan pada kawasan sawit yang berumur 3 dan 5 tahun.

Tabel 3. Rata-rata hasil analisis laboratorium untuk hara N, P dan K dalam aliran permukaan

	Kode	NH_3 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	N-Total (mg/l)	P total (mg/l)	K Total (mg/l)
Minimum	Sawit 3 Tahun	0,00	0,01	0,01	0,02	0,02	0,01
	Sawit 5 Tahun	0,00	0,01	0,01	0,02	0,01	0,36
	Hutan	0,00	0,01	0,01	0,02	0,02	0,59
Maksimum	Sawit 3 Tahun	0,49	0,02	0,85	0,86	22,57	4,18
	Sawit 5 Tahun	0,63	0,09	0,31	0,69	0,12	1,22
	Hutan	0,25	0,04	0,28	0,29	0,24	4,55
Rata-Rata	Sawit 3 Tahun	0,08	0,01	0,22	0,31	3,71	1,02
	Sawit 5 Tahun	0,10	0,02	0,08	0,19	0,04	0,77
	Hutan	0,05	0,02	0,11	0,17	0,09	2,36

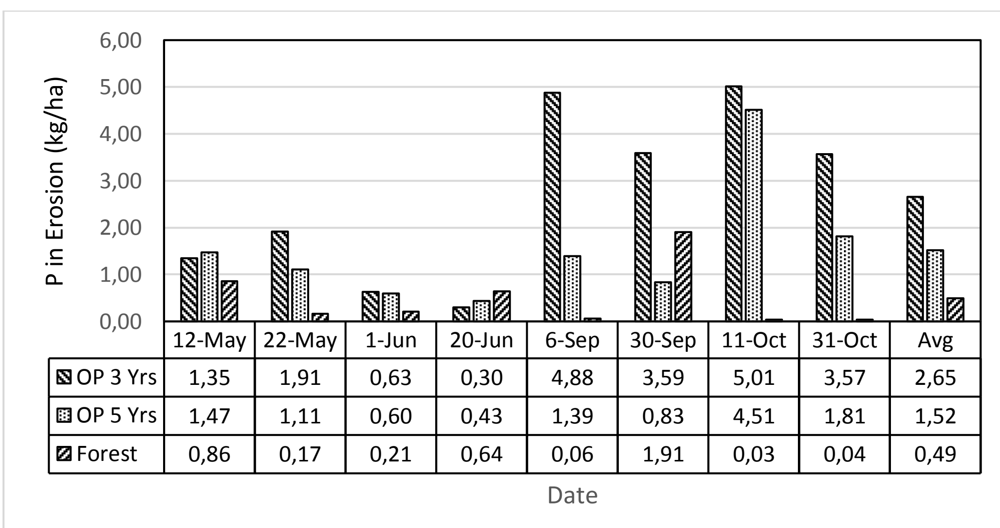
Berdasarkan pada Tabel 2, tampak bahwa kandungan unsur hara N total dalam aliran permukaan pada plot tanaman sawit berumur 3 tahun adalah antara 0,02-0,86mg/l dan rata-rata 0,31 mg/l; 0,02-0,69 mg/liter dengan rata-rata sebesar 0,19 mg/liter (sawit 5 tahun) dengan porsi terbesar dalam bentuk amoniak (NH_3), antara 0,02-0,29mg/l dan rata-rata 0,17mg/l (hutan). Untuk P-total berkisar antara 0,02-22,57mg/l dan rata-rata 0,04 mg/l (sawit 3 tahun) 0,01-0,12 mg/liter dengan rata-rata sebesar 0,04 mg/liter (sawit 5 tahun); 0-02-0,24 mg/l dan rata-rata 0,09 mg/l (hutan). Untuk total kandungan hara K dalam aliran permukaan sebesar 0,01-4,18 mg/l dan rata-rata 1,02 mg/l (sawit 3 tahun); 0,36-1,22 mg/liter dengan rata-rata sebesar 0,77 mg/liter (sawit 5 tahun); 0,59-4,55 mg/l dan rata-rata 2,36 mg/l (hutan). Dengan demikian secara umum kandungan unsur hara N, P dan K yang terbawa aliran permukaan dari kawasan hutan lebih tinggi dibandingkan pada kawasan sawit yang berumur 3 dan 5 tahun.

Konsentrasi hara dalam sedimen tererosi dan jumlah erosi menentukan jumlah unsur hara yang hilang dalam erosi dan besarnya kehilangan hara untuk N, P dan K disajikan pada Gambar 5, 6 dan 7. Berdasarkan pada Gambar 5, tampak bahwa kandungan unsur hara N total dalam sedimen tererosi pada plot tanaman sawit berumur 3 tahun berkisar antara 1,16-35kg/ha (rata-rata 12,90 kg/ha) dan untuk sawit 5 tahun berkisar antara 1,19-39,48kg/ha (rata-rata 13,04 kg/ha) dan hutan antara 0,42-6,80 kg/ha (rata-rata 1,93 kg/ha). Pada Gambar 6, tampak bahwa kehilangan P-total dalam erosi pada sawit 3 tahun berkisar antara 0,30-5,01 kg/ha (rata-rata 2,65 kg/ha), diikuti tanaman sawit 5 tahun 0,43-4,51 kg/ha (rata-rata 1,52 kg/ha) dan hutan antara 0,03-1,91 kg/ha (rata-rata 0,49 kg/ha). Untuk total kandungan hara K dalam sedimen tererosi seperti diperlihatkan pada Gambar 7, dari plot penelitian pada sawit 5 tahun kehilangan K dengan kisaran antara 0,92-62,82 kg/ha (rata-rata 15,17kg/ha) diikuti sawit 3 tahun antara 0,45-32,38kg/ha (rata-rata sebesar 10,46 kg/ha) dan hutan sebesbar 0,33-3,42 kg/ha (rata-rata 1,61 kg/ha). Dengan demikian secara keseluruhan kandungan unsur hara N, P dan K yang terbawa hilang terbawa dalam erosi tanah dari kawasan perkebunan kelapa sawit berumur 3 dan 5 tahun lebih tinggi dibandingkan pada kawasan hutan.



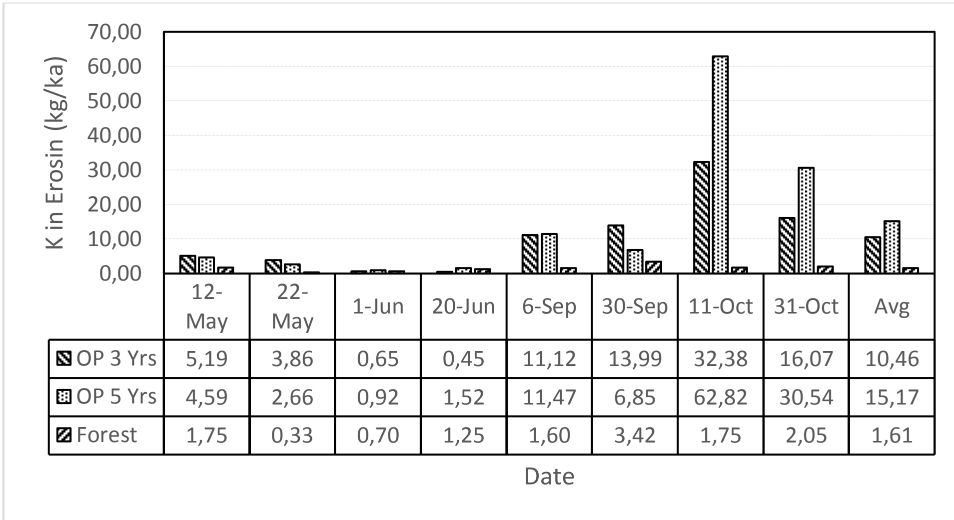
	12-May	22-May	1-Jun	20-Jun	6-Sep	30-Sep	11-Oct	31-Oct	Avg
OP 3 Yrs	16,09	21,78	5,29	4,65	3,97	25,60	24,62	1,16	12,90
OP 5 Yrs	18,15	16,48	9,55	9,90	1,19	2,35	7,19	39,48	13,04
Forest	1,00	1,53	2,18	6,80	0,42	0,47	1,14	1,94	1,93

Gambar 5. Unsur hara N yang terbawa dalam Erosi pada plot kebun sawit berumur 3 dan 5 tahun serta kawasan hutan



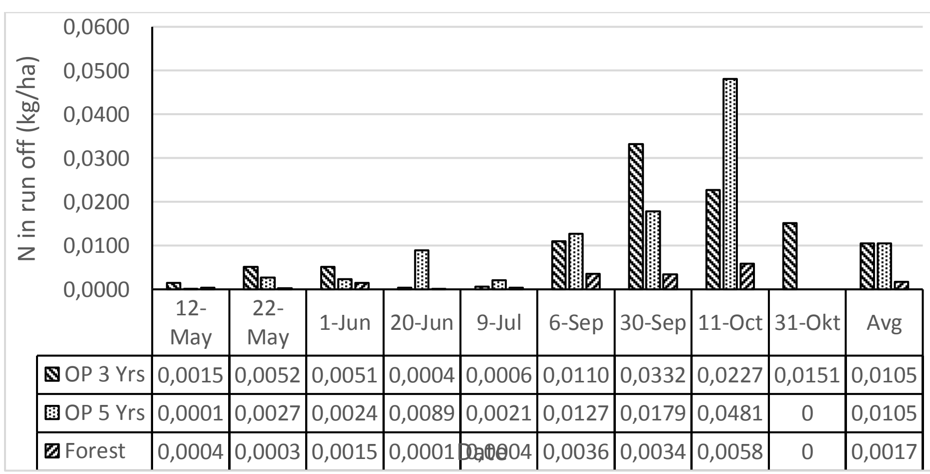
	12-May	22-May	1-Jun	20-Jun	6-Sep	30-Sep	11-Oct	31-Oct	Avg
OP 3 Yrs	1,35	1,91	0,63	0,30	4,88	3,59	5,01	3,57	2,65
OP 5 Yrs	1,47	1,11	0,60	0,43	1,39	0,83	4,51	1,81	1,52
Forest	0,86	0,17	0,21	0,64	0,06	1,91	0,03	0,04	0,49

Gambar 6. Unsur hara P yang terbawa dalam Erosi pada plot kebun sawit berumur 3 dan 5 tahun serta kawasan hutan

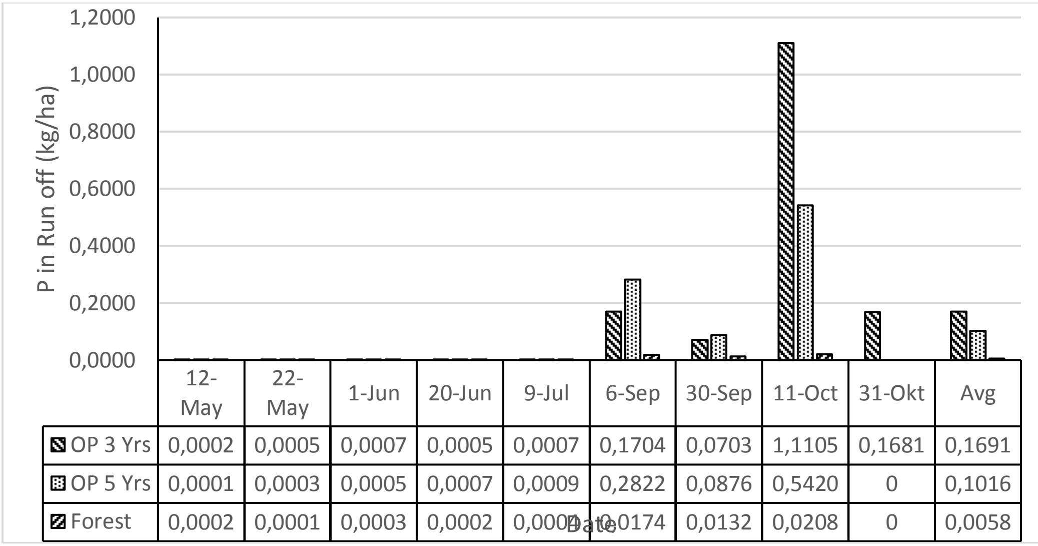


Gambar 7. Unsur hara K yang terbawa dalam Erosi pada plot kebun sawit berumur 3 dan 5 tahun serta kawasan hutan

Unsur hara yang hilang melalui aliran permukaan merupakan kombinasi antara volume aliran permukaan dan kandungan unsur hara dalam aliran permukaan tersebut. Berdasarkan pada Gambar 8, tampak bahwa unsur hara N total dalam aliran permukaan pada plot tanaman sawit berumur 3 tahun berkisar antara 0,004-0,0332 kg/ha (rata-rata 0,0105 kg/ha) diikuti sawit 5 tahun berkisar antara 0-0,481 kg/ka (rata-rata 0,0105kg/ha) dan hutan antara 0-0,0058 kg/ha (rata-rata 0,0017kg/ha), dengan porsi terbesar dalam bentuk amoniak (NH_3). Untuk P-total (Gambar 9) kehilangannya berkisar antara 0,0002-1,1105 kg/ha (rata-rata 0,1691kg/ha) untuk sawit berumur 3 tahun diikuti sawit 5 tahun antara 0-0,5420 kg/ha (rata-rata 0,1016kg/ha) dan hutan antara 0-0,0174kg/ha (rata-rata 0,0058 kg/ha).



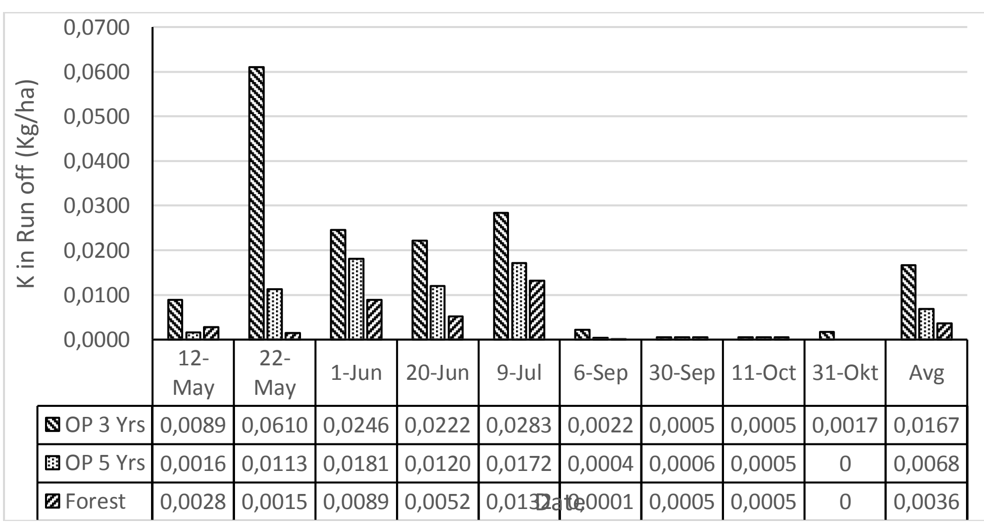
Gambar 8. Unsur hara N yang terbawa dalam Aliran Permukaan pada plot kebun sawit berumur 3 dan 5 tahun serta kawasan hutan



	12-May	22-May	1-Jun	20-Jun	9-Jul	6-Sep	30-Sep	11-Oct	31-Okt	Avg
OP 3 Yrs	0,0002	0,0005	0,0007	0,0005	0,0007	0,1704	0,0703	1,1105	0,1681	0,1691
OP 5 Yrs	0,0001	0,0003	0,0005	0,0007	0,0009	0,2822	0,0876	0,5420	0	0,1016
Forest	0,0002	0,0001	0,0003	0,0002	0,0004	0,0174	0,0132	0,0208	0	0,0058

Gambar 9. Unsur hara P yang terbawa dalam Aliran Permukaan pada plot kebun sawit berumur 3 dan 5 tahun serta kawasan hutan

Untuk total kandungan hara K dalam aliran permukaan (Gambar 10) pada plot kebun sawit 3 tahun sebesar 0,0005-0,0610 kg/ha (rata-rata 0,0167) diikuti kebun sawit 5 tahun yaitu sebesar 0-0,0181 kg/ha (rata-rata 0,0068 kg/ha) dan hutan antara 0-0,0132 kg/ha (rata-rata 0,0036kg/ha). Dengan demikian secara keseluruhan kandungan unsur hara N, P dan K yang terbawa aliran permukaan dari kawasan sawit yang berumur 3 tahun lebih tinggi daripada sawit 5 tahun dan diikuti pada kawasan hutan.

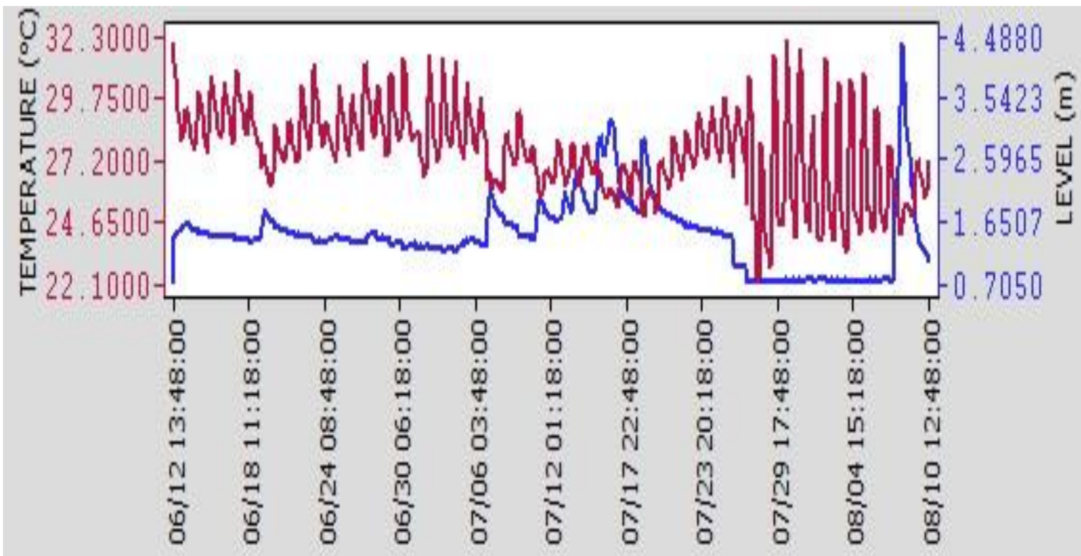


	12-May	22-May	1-Jun	20-Jun	9-Jul	6-Sep	30-Sep	11-Oct	31-Okt	Avg
OP 3 Yrs	0,0089	0,0610	0,0246	0,0222	0,0283	0,0022	0,0005	0,0005	0,0017	0,0167
OP 5 Yrs	0,0016	0,0113	0,0181	0,0120	0,0172	0,0004	0,0006	0,0005	0	0,0068
Forest	0,0028	0,0015	0,0089	0,0052	0,0132	0,0001	0,0005	0,0005	0	0,0036

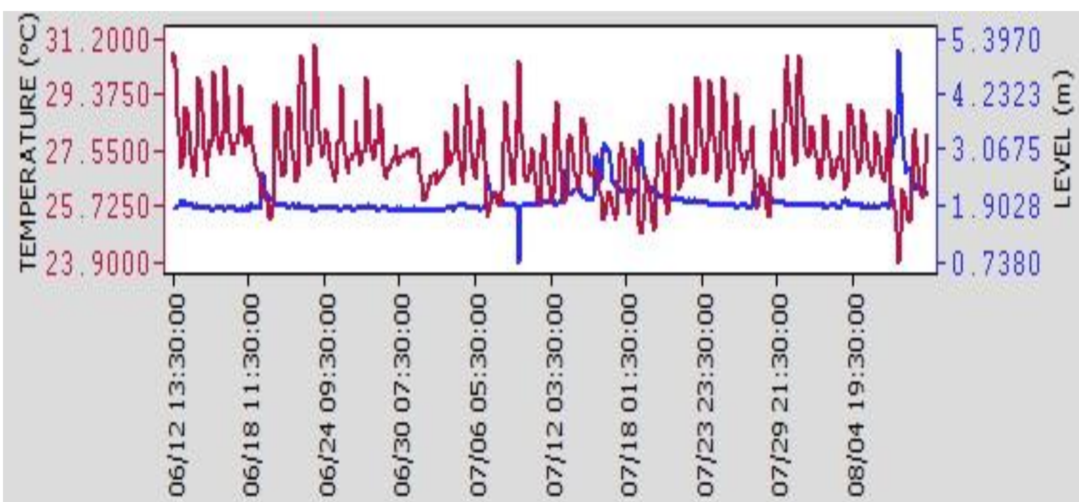
Gambar 10. Unsur hara K yang terbawa dalam Aliran Permukaan pada plot kebun sawit berumur 3 dan 5 tahun serta kawasan hutan

Hasil penelitian yang dikemukakan beberapa peneliti menyebutkan bahwa DAS dengan vegetasi hutan, NO_3 memberikan kontribusi kehilangan sebesar 34% dari hilangnya nitrogen dan DON adalah output utama sebesar 55%. Hilangnya NO3 dalam setahun lebih rendah di daerah tangkapan air dengan hutan asli dibandingkan dengan tangkapan dengan perkebunan di mana output debit sungai melebihi masukan curah hujan (Carlos Oyarzun, Claudia Aracena, Patricio Rutherford, Roberto Godoy dan An Deschrijver, 2007).

5. Penelitian Dalam DAS Jalemu



Gambar 11. Tinggi Muka Air pada Sub DAS Batang Jalemu



Gambar 12. Tinggi Muka Air pada SubDAS Jalemu Haluli

6. Sampling dan analisis tanah

Dilakukan sampling tanah baik sampel terganggu maupun sampel tanah tidak terganggu pada tiga penggunaan lahan yang berbeda sesuai perlakuan sebelumnya yaitu 1) sawit berumur 3 tahun, 2) sawit berumur 5 tahun dan 3) kawasan hutan. Saat ini sedang dilakukan analisis unsur hara berupa N, P, K, Basa-Basa, KTK dan C organik serta bobot isi tanah.

BAB 6. KESIMPULAN DAN SARAN

Kesimpulan

1. Curah hujan terbesar selama periode penelitian terjadi pada bulan Oktober yaitu sebesar 459,5 mm sedangkan terkecil terjadi pada Bulan Juni 2017. Untuk jumlah hari hujan terbanyak berlangsung pada Bulan Nopember yakni sebanyak 24 hari sedangkan jumlah hari hujan terendah ada pada Bulan Mei yakni sebanyak 7 hari.
2. Erosi dan aliran pada perkebunan kelapa sawit berumur 3 tahun dan 5 tahun lebih besar dari kawasan hutan dan hal tersebut terjadi pada sebagian besar kejadian hujan. Rata-rata erosi yang terjadi pada pada perkebunan kelapa sawit sawit berumur 3 tahun adalah 0,10 ton/ha dan 5 tahun adalah 0,09 ton/ha, dan pada kawasan hutan sebesar 0,002 ton/ha. Rata-rata aliran permukaan yang terjadi pada pada perkebunan kelapa sawit sawit berumur 3 tahun, 5 tahun dan pada kawasan hutan secara berutuan sebesar 2,83 mm, 2,46 mm dan 0,52 mm.
3. Kandungan hara yang terbawa hilang terbawa dalam erosi dan aliran permukaan dari kawasan perkebunan kelapa sawit berumur 3 tahun dan 5 tahun lebih tinggi dibandingkan pada kawasan hutan dan pada seluruh tutupan lahan tersebut sebagian besar hara hilang terbawa bersama sedimen, dan hanya sebagian kecil dalam air aliran permukaan.
4. Kandungan N total dalam sedimen tererosi dan aliran permukaan pada tanaman sawit berumur 3 tahun, 5 tahun dan hutan secara berututan masing-masing adalah 12,91 kg/ha, 13,05 kg/ha dan 1,94 kg/ha. Kandungan P-total yang hilang dalam aliran dan erosi sebesar 2,82 kg/ha, 1,62 kg/ha dan 0,50 kg/ha, sedangkan kehilangan K rata-rata sebesar 10,48 kg/ha, 15,18 kg/ha dan 1,61 kg/ha.

Saran

Perlu dilakukan penelitian lanjutan dengan menerapkan perlakuan teknik konservasi tanah dan air pada kawasan perkebunan kelapa sawit dalam skala yang lebih luas dalam sakala DAS untuk mengurangi dampak yang ditimbulkan dari erosi dan aliran permukaan khususnya dari kawasan perkebunan kelapa sawit.

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DAFTAR PUSTAKA

Ariesca, Reza. 2004. Studi Tentang Terjadinya Erosi, Aliran Permukaan, dan Hilangnya Unsur Hara Dalam Aliran Permukaan Pada Lahan hutan Sekunder 1 Tahun BekasTerbakar. *Skripsi*. Bogor: Depertemen Manajemen Hutan Fakultas Kehutanan InstitutPertanian Bogor.(Online).(http://repository.ipb.ac.id/ bitstream/handle/123456789/ 19012/ E04RAR.pdf?sequence=2,diakses 11 Oktober 2012).

Arsyad, S. 2006. Konservasi Tanah dan Air, Fakultas Pertanian IPB. IPB Press, Cetakan Ke Tiga. Gedung Lembaga Sumberdaya Informasi Lt. 1 Kampus Darmaga, Bogor.

Arsyad, U. 2010. *Analisis Erosi Pada Berbagai Tipe Penggunaan Lahan dan Kemiringan Lereng di Daerah Aliran Sungai Jeneberang Hulu.* Disertasi Program Pascasarjana Universitas Hasanuddin, UNHAS. Makassar.

Asdak, 2002. *Hidrologi dan Pengelolaan Daerah Aliran Sungai*. Gadjah Mada University Press: Yogyakarta.

Bafdal, N. 2000. Pengaruh naungan terhadap laju erosi pada berbagai pola tanam dan kermiringan lahan; Laporan Penelitian,Lembaga Penelitian UNPAD.

Best A, Zhang L, McMahon Tet al. (2003) A critical review of paired catchment studies with reference to seasonal flows and climatic variability. CSIRO land and water technical report 25/03, CSIRO, Canberra, Australia, 30pp.

Blanco. H., Lal., R., 2008. Principles of Soil Conservation and Management. Springer Science+Business Media B.V.

Bosch JM, Hewlett JD (1982) A review of catchment experiments to determine the effect of vegetation changes on water yield and evapotranspiration. Journal of Hydrology, 55, 3–23.

Bosch JM, von Gadow K (1990) Regulating afforestation for water conservation in South Africa. South African Forestry Journal, 153, 41–54.

Breure, K. 2003 The search for yield in oil palm: Basic principles. In "Oil Palm: Management for Large and Sustainable Yields" (T. Fairhurst and R. Hardter, Eds.), pp. 59–98. Potash & Phosphate Institute/Potash Institute of Canada and International Potash Institute, Singapore.

Brooks KN, Ffolliott PF, Gregersen HM et al. (1997) Hydrology and the Management of Watersheds, 2nd edition. Iowa State University Press, Ames.

Campiglia E, Mancinelli R, Radicetti E, Marinari S 2010 Legume cover crops and mulches: effects on nitrate leaching and nitrogen input in a pepper crop (Capsicumannuum L.). Nutr. Cycl. Agroecosyst. 89:399-412.

Cannell, MGR. (1999) Environmental impacts of forest monocultures: water use, acidification, wildlife conservation, and carbon storage. New Forests, 17, 239–262.

Carlos Oyarzun, Claudia Aracena, Patricio Rutherford, Roberto Godoy dan An Deschrijver, 2007. Effects of Land Use Conversion from Native Forests to Exotic Plantations on Nitrogen and Phosphorus Retention in Catchments of Southern Chile. Water Air Soil Pollut (2007) 179:341–350.

Carlos Oyarzun, Claudia Aracena, Patricio Rutherford, Roberto Godoy dan An Deschrijver, 2007. Effects of Land Use Conversion from Native Forests to Exotic Plantations on Nitrogen and Phosphorus Retention in Catchments of Southern Chile. Water Air Soil Pollut (2007) 179:341–350.

Environment Conservation Department. 2000. Environmental impact assessment (EIA) guidelines on oil palm plantation development. Environmental Conservation Department, Sabah, Malaysia. Available at: http://www.sabah.gov.my/jpas/programs/ecd-cab/technical/OP211100.pdf. (Consulted on Apr 13th, 2011)Goh dan Chew (1995)

Goh K J, Härdter R. and Fairhurst T 2003 Fertilizing for maximum return. In: Fairhurst T, Hardter R (eds) Oil Palm: Management for Large and Sustainable Yie. Potash & Phosphate Institute/Potash & Phosphate Institute of Canada and International Potash Institute (PPI/PPIC and IPI, Singapore, pp 279–306.

Hanafiah, Kemas Ali. 2005. *Dasar-Dasar Ilmu Tanah.* Jakarta: Devisi Buku Perguruan Tinggi. RajaGrafindo Persada.

Harahap I. Purba A. Poeloengan. 1996. Aplikasi Model Neraca Air Harian Agrometeorologis Untuk Memprediksi Lengas Tanah Pada Pertanaman Kelapa Sawit. Jurnal Penelitian Kelapa Sawit 4(3): 121 -134.

Harahap, I.Y. and W. Darmosarkoro, 1999. Pendugaan kebutuhan air untuk pertumbuhan kelapa sawit di lapang dan aplikasinya dalam pengembangan sistem irigasi. Jumal Penelitian Kelapa Sawit, 7: 87-104.

Haridjaja, O., K. Murtilaksono., Sudarmo., dan L. M. Rachman. 1990. Hidrologi Pertanian. Jurusan Tanah, Fakultas Pertanian, Institut Pertanian Bogor. Bogor.

Hoffmann WA, Jackson RB (2000) Vegetation–climate feedbacks in the conversion of tropical savanna to grassland. Journal of Climate, 13, 1593–1602.

Holmes JW, Sinclair JA (1986) Water yield from some afforested catchments in Victoria. Hydrology and Water Resources Symposium. River Basin Management, Griffith University, Brisbane, 25–27 November 1986, Institution of Engineers,Australia, Barton, ACT, Australia.

Indonesian Ministry of Agriculture 2010 Area and production by category of producers: palm oil, Direktor at Jenderal Perkebunan. KementerianPertanian. Availableat: http://ditjenbun.deptan.go.id/index.php/direktori/3-isi/4-kelapa-sawit.html. (Consultedon April 13th, 2011)

Jackson RB, Carpenter SR, Dahm CN et al. (2001) Water in a changing world. Ecological Applications, 11, 1027–1045.

Kartasapoetra AG. 1986. *Pengaruh Iklim Terhadap Tanah dan Tanaman*. Jakarta:Bumi Aksara

Kartasapoetra, G., Sutedjo Mul Mulyani. 2003. *Teknologi Konservasi Tanah & Air*. Jakarta: Rineke Cipta

Kundarto. 2005. Neraca air, Erosi tanah dan Traspor Lateral Hara NPK Pada Sistem Persawahan di Sub DAS Kali Babon,Semarang.http://www.google.co.id/ur. balittanah.litbang.deptan.go.id%2Fdokumentasi%2Fprosiding%2Fmflp2003%2Fkundarto17. [4 Juli 2011]. Lembaga Sumberdaya, IPB. Bogor Press.

Martono. 2004. Pengaruh Intensitas Hujan dan Kemiringan Lereng terhadap Laju Kehilangan Tanah pada Tanah Regosol Kelabu. Tesis. Semarang: Universitas Diponegoro.

Morgan. R.C.P., 2001. Soil Erosion and Conservation. Third Edition. Blackwell Publishing.

Murtilaksono, K, Siregar, H.H., Darmosarkoro, W. Model neraca air di perkebunan kelapa sawit (*water balance model in oil palm plantation*).

Murtilaksono, K., Siregar, H.H., Darmosarkoro, W., dan Hidayat, Y. Model Perhitungan Neraca Air Kebun Kelapa Sawit Di Unit Usaha Rejosari,Lampung

Nykvist, Grip, Liang Sim, Malmers, & Khiong Wong, 1994).

Pasaribu, H., Mulyadi, A., dan Tarumun, S. 2102. Neraca Air di Perkebunan Kelapa Sawit di PPKS Sub Unit Kalianta Kabun Riau. Jurnal Ilmu Lingkungan 6 (2) : 99-113.

Pearce AJ, Rowe LK (1979) Forest management effects on interception, evaporation, and water yield. Journal of Hydrology New Zealand, 18, 73–87.

Rahim, S. E. 2003. Pengedalian Erosi Tanah dalam Rangka Pelestarian Lingkungan Hidup. Edisi I. Bumi Aksara. Jakarta.

Robinson M, Cognard-Plancq AL, Cosandey C et al. (2003) Studies of the impact of forests on peak flows and baseflows: a European perspective. Forest Ecology and Management, 186, 85–97.

Schilling, K.E., 2007. Water table fluctuations under three riparian land covers, Iowa (USA). Hydrol. Process., 21: 2415-2424.

Scott DF, Prinsloo FW,Moses G et al. (2000) A re-analysis of the South African catchment afforestation experimental data. WRC Report No 810/1/00, Water Research Commission, Pretoria, South Africa.

Scott DF, Smith RE (1997) Preliminary empirical models to predict reductions in total and low flows resulting from afforestation. Water SA, 23, 135–140.

Seyhan, Ersin. 1990. Dasar-dasar Hidrologi.*Diterjemahkan* oleh Ir. Sentot Subagyo. GadjahMada University Press, Yogyakarta.

Sharda VN, Samraj P, Samra JS et al. (1998) Hydrological behaviour of first generation coppiced bluegum plantations in the Nilgiri sub-watersheds. Journal of Hydrology, 211, 50–60.

Sheil D, Casson A, Maijaard E, van Noordwijk M, Gaskell J, Sunderland G J, Wertz K, and Kanninen M 2009 The impacts and opportunities of oil palm in Southeast Asia. Center for International Forestry Research, Bogor.

Smith D .1945. Investigation in Erosion Control and Reclamation of Erosion Shelby and Related Soils, Bethany, 1930-1942. USDA Agr.

Smith RE, Scott DF (1992) The effects of afforestation on low flows in various regions of South Africa.Water SA, 18, 185–194.

Sukartaatmadja, S. 1998. Perlindungan Lereng dan Pengendalian Erosi Menggunakan Vegetasi Penutup. Jurusan Teknik Pertanian, Fakultas Teknologi Pertanian. IPB.

Susanti A and Burgers P P M 2012 Oil palm expansion in Riau province, Indonesia: serving people, planet, profit? Background Paper to the 2011/2012 European Report on Development: Confronting Scarcity: Managing Water, Energy and Land for Inclusive and Sustainable Growth. European Union, Brussels. Available at : http://erd-report.eu/erd/report_2011/documents/researchpapers_susanti-burgers.pdf (Consulted on January 27th, 2015)

Vertessy RA (1999) The impacts of forestry on streamflows: a review. In: Forest Management for Water Quality and Quantity. Proceedings of the Second Forest Erosion Workshop, May 1999,

Vertessy RA (2001) Impacts of plantation forestry on catchment runoff. In: Plantations, Farm Forestry, and Water. Water and Salinity Issues in Agroforestry no. 7, RIRDC Publication No. 01/20 (eds Nambiar EKS, Brown AG), pp. 9–19. RIRDC, Kingston, Australia.

Vertessy RA, Bessard Y (1999) Anticipating the negative hydrologic effects of plantation expansion: results from a GIS-based analysis on the Murrumbidgee Basin. In: Forest Management for Water Quality and Quantity. Proceedings of the Second Forest Erosion Workshop, May 1999, Warburton, Australia. Report 99/6 (eds Croke J, Lane P), pp. 69–73. Cooperative Research Centre for Catchment Hydrology, CSIRO Land and Water, Canberra, Australia.

Vitousek P M, Aber J D, Howarth R W, Likens G E, Matson P A, Schindler D W 1997. Technical report: Human alteration of the global nitrogen cycle: Sources and consequences. Ecological Applications, 7(3), 737–750.

Vitousek, P. M., Aber, J. D., Howarth, R. W., Likens, G. E., Matson, P. A., Schindler, D. W., et al. (1997). Technical report: Human alteration of the global nitrogen cycle: Sources and consequences. Ecological Applications, 7(3), 737–750.

Widodo. 2011. Estimasi Nilai Lingkungan Perkebunan Kelapa Sawit Ditinjau Dari Neraca Air Tanaman Kelapa Sawit. Karya Ilmiah. Fakultas Matematika dan Ilmu Pengetahuan Alam. Institut Pertanian Bogor. Bogor.

Wischmeir WH. 1978. Use and Misuse of the universal soil loss equation. J Soil and Water Conservasion. 31 (1) : 59.

Zhang L, Dawes WR, Walker GR (1999) Predicting the Effect of Vegetation Changes on Catchment Average Water Balance. Cooperative Research Centre for Catchment Hydrology, CSIRO Land and Water, Canberra, ACT, Australia.

EROSION AND SURFACE RUNOFF ON FOREST AND OIL PALM PLANTATION IN JALEMU WATERSHED, GUNUNG MAS REGENCY, CENTRAL KALIMANTAN PROVINCE

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ABSTRACT

Changes in land cover from forest to non-forest areas affect the hydrological cycle and water quality in watershed ecosystems, such as the changing into oil palm plantation areas. Increased production and extent of oil palm plantations have an impact on the environment and water damage, and has become one of the environmental issues. Research was conducted to provide an overview of the erosion and surface runoff from forest and oil palm plantations and its impact on the water quality. Research plots on erosion 15 m x 25 m was made on Jalemu Watershed, Gunung Mas Regency, Central Kalimantan Province. The research was conducted to study the impact of land cover changes on erosion and surface runoff and nutrients lost into the Jalemu River Basin. Sampling of sediment and water were carried out from erosion reservoir and surface stream and also water sampling from Jalemu watershed. The results showed that the erosion and surface runoff that occurred in the 5 years old oil palm area were larger than in the forest area, as well as implied the loss of nutrients from oil palm plantation areas and the potential for water pollution by the nutrients.

Keywords: Erosion, surface runoff, nutrients loss, oil palm

ABSTRAK

Perubahan tutupan lahan dari kawasan hutan menjadi kawasan non hutan diyakini akan berpengaruh pada kondisi hidrologi dan kualitas air dalam ekosistem daerah aliran sungai

(DAS), salah satunya adalah konversi menjadi kawasan perkebunan sawit. Peningkatan produksi dan luasan tanaman sawit memberikan dampak pada lingkungan dan kerusakan perairan yang disebabkan oleh perkebunan kelapa sawit, dan telah menjadi salah satu isu yang lingkungan. Penelitian dilakukan untuk memberikan gambaran erosi dan aliran permukaan dari perkebunan kelapa sawit dan dampaknya pada perairan. Penelitian pada plot erosi berukuran masing-masing 15 m x 25 meter dibuat pada kawasan DAS Jalemu, Kabupaten Gunung Mas, Provinsi Kalimantan Tengah, yang mencakup kawasan perkebunan kelapa sawit dan dan hutan, untuk mempelajari dampak perubahan tutupan lahan terhadap tingkat erosi dan aliran permukaan serta hara yang hilang dalam kedua proses tersebut yang akan mengalir ke DAS Jalemu. Sampling sedimen dan air dilakukan dari bak penampung erosi dan aliran permukaan serta dilakukan pula sampling air dari DAS Jalemu. Hasil penelitian menunjukkan bahwa aliran erosi dan aliran permukaan yang terjadi pada kawasan sawit yang berumur 5 tahun lebih besar dari yang terjadi dikawasan hutan dan hal ini juga berimplikasi pada hilangnya unsur hara dari kawasan perkebunan kelapa sawit dan potensi pencemaran perairan oleh unsur hara tersebut.

Kata Kunci : erosi, aliran permukaan, kehilangan hara, kelapa sawit

INTRODUCTION

Production of oil palm (*Elaeis guineensis*) had grown rapidly in the tropics over the past decade. As the world's largest palm oil producer since 2007, the Indonesian Government plans to increase production to 40 million tons of coconut crude by 2020, mainly in Sumatra, Kalimantan and West Papua (IMA, 2010). Riau Province in Central Sumatra is the largest producer of palm oil in Indonesia, around 24% of the total national production. From 2004 to 2009, the area of oil palm in Riau Province increased by 21% (IMA 2010; Susanti and Burgers 2012), and in its development the region of Central Kalimantan also increased the area of oil palm cultivation and production. The development of the area of oil palm plantations in particular in Central Kalimantan is quite large as well as the increasing in production has increased very rapidly. Palm oil was one the major industry who increased the economy as well as the largest producer to non-oil and gas exports in Indonesia (Susila, 2004). Rapid expansion such as the palm oil industry shows that extraordinary land use changes were taking place in Indonesia, which raised concern for the environment and human health.

Various environmental issues continue to occur in relation to the development of oil palm plantations, including issues related to water conditions in the region and water quality. Regarding the deterioration of the water crisis in various regions, some people have accused that oil palm companies had a lot to contribute to the waste water discharge to run their plantations. Issues concerning disruption of regional water systems caused by the development of oil palm have spread as environmental issues. Oil palm plantations were considered to be the caused of reducing the availability of groundwater as well as the level of groundwater. These challenges were feared to affect the level of productivity and export volume of palm oil and its derivative production. The issue of greedy oil palm plantations being one of the environmental issues as the impact of oil palm plantations in an area, but there is no data to support these accusations. Along with the erosion and surface runoff that occurs from oil palm plantations, there were indications that it will lead to a change in water quality in the aquatic ecosystem around the location of oil palm plantations related to nutrients both dissolved and transported in the sediment. Provisional allegations that water loss and disruption of the water system in an area were caused more by the loss of water storage function on plantation land and not by consumption of oil palm plants.

Most activities related to the development of oil palm plantations and exploitation (eg forest clearing, road construction and drainage networks, use of agricultural chemicals and the release of wastewater) present risks to land surface and groundwater quality (ECD 2000; Goh *et al.* 2003.) Hydrological conditions and aquatic ecosystems close to plantations were very risky for decreasing water quality because fertilization is applied on plantations at a relatively high level (Sheil *et al*. 2009). Runoff and drainage water from oil palm plantations is controlled by cover crops planted legumes. However, the understorey is disappearing due to the closed canopy of the oil palm plant, with vegetation cover to maintain excess water and nutrient-rich sediments. Furthermore, the decomposition of the cover legume under the adult canopy releases nitrogen that previously occurred through nitrogen fixation (Breure 2003; Campiglia *et al* 2010; Goh *et al*. 2003). Goh and Chew (1995) asserted that the nitrate loss of washing from legume plants was influenced by soil texture and greater recorded losses in sandy soils. Conversion of land use, especially from forests to agricultural or grassland land, greatly influences nutrient fluxes in the watershed (Vitousek *et al*. 1997). The effect of converting forests to plantations on nitrogen and phosphorus is completely not understood. Vegetation substitution by logging practices might have an impact on river water quality through loss of

biomass, variable amounts of slash logging on forest floor, accelerated soil erosion and N mineralization (Nykvist, Grip, Liang Sim, Malmers, & Khiong Wong, 1994).
The purpose of this research to study magnitude of erosion and surface runoff in the watershed area that covers the area of oil palm plantations. The results of this study, a portion will be answered which causes the potential damage caused by land degradation in a watershed area.

MATERIAL AND METHODS

The research was carried out on forest land and oil palm plantations owned by PT. KHS included in the Jalemu Watershed, Manuhing Subdistrict, Gunung Mas Regency as presented in Figure 1. The study was conducted for 4 months consisting of 2 stages, namely data collection in the June-September 2017 field and erosion soil analysis and surface runoff stages in Analytical Laboratory, University of Palangka Raya.

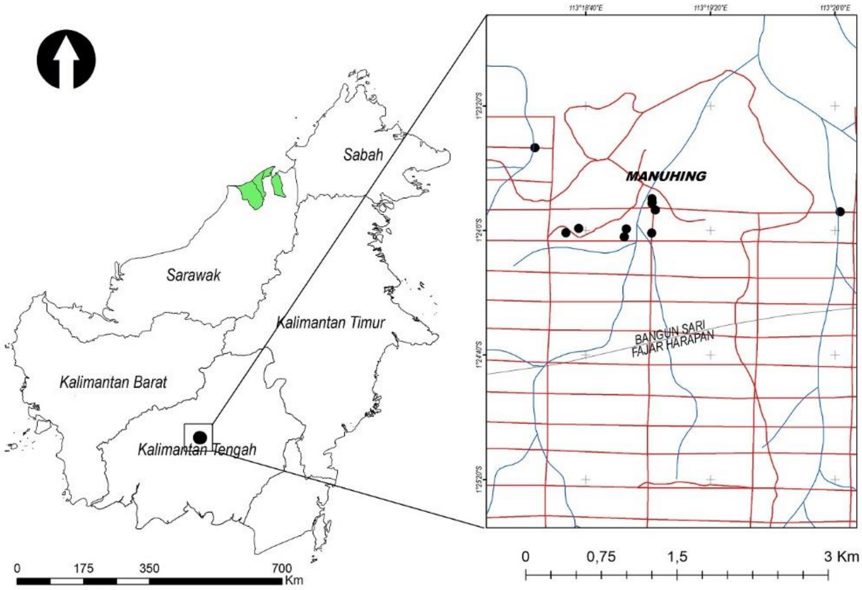

Figure 1. Map of research location in Jalemu Watershed which mainly dominated by oil palm plantation

This research was conducted in the field with two land cover factors and two replications. The research plots user forests and oil palm area who was 5 years old. Erosion plots were made at each trial site with 15 m × 25 m with each side of the map mounted zinc with a height of 20 cm above the ground surface. The erosion collection box and the surface runoff used were 5 m × 0.5 m x 0.5 m, and on the side there were 7 holes with a diameter of 2.5 inches. The middle hole was connected by 2.5 inch pipe (Figure 2). Measurement of erosion and surface runoff was carried out following each rainfall event during the study. The amount of soil and sediment

(E) was carried out by wet weighing in the field. Sediment samples were taken to determine moisture content by drying in an oven at 105 ºC for 24 hours. The volume of surface runoff determined in the field and sampling was also carried out to analyze the nutrient content in the surface runoff. Data collected were analized by using descriptive analysis to compare of each factor.

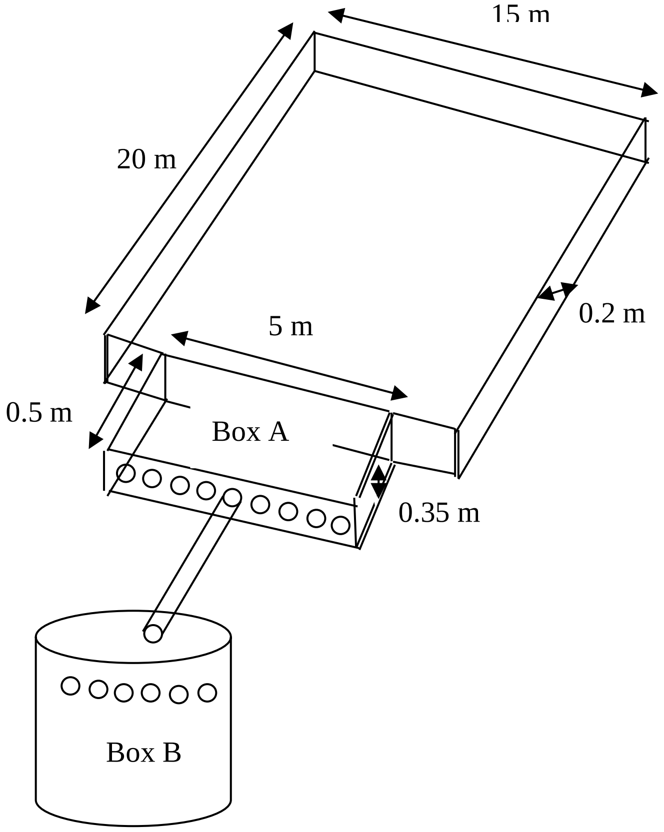

Figure 2. Frame-work of erosion and surface runoff

Laboratory activities for water and sediment analysis were carried out at the Analytical Laboratory, University of Palangka Raya. Sediment analysis was carried out to measure the concentration of Total N (Kjeldhal), Total P (Bray I with spectrophotometer), and Total K (NH_4OAc pH 7.0 with a Flamephotometer). Water analysis includes NH_3 (Kjedhal), NO_2 (Sulfanilamide) and NO_3 (Colorimetric) and P (Spectrophotometer) and K (Atomic Absorption Spectrophotometer, AAS). The results of the Total N, P and K analysis through erosion or surface runoff were calculated by the following equation:

$X = Y \times E$

Remarks:

X = N, P and K lost due to erosion (kg plot^{-1} or g plot^{-1}) or surface runoff (kg ha^{-1})

Y = Total N (%), P (ppm) and K (me 100 g^{-1} soil) concentrations in sediment or in surface runoff (mg L^{-1})

E = Total soil erosion (kg plot^{-1}) or volume of surface runoff (liters)

RESULTS AND DISCUSSION

Rainfall

Rainfall data was recorded using a tipping bucket type ombrometer during the study. Field observations showed 117 rainy days observed in the period May 2017 to February 2018. Patterns of rainfall decrease in each treatment in the dry season period, namely in May and June. The largest rainfall during the study period occurred in October amounting to 459.5 mm while the smallest occurred in June 2017. The highest number of rainy days took place in November, which was 24 days while the lowest number of rainy days was in May, which was 7 days.

Erosion and Surface Runoff

The results of the calculation of erosion and surface runoff that occurred in the erosion plot for several rainfall events for both erosion plots in forest areas and on erosion plots in 5 years old oil palm plantations were presented in Figure 3.

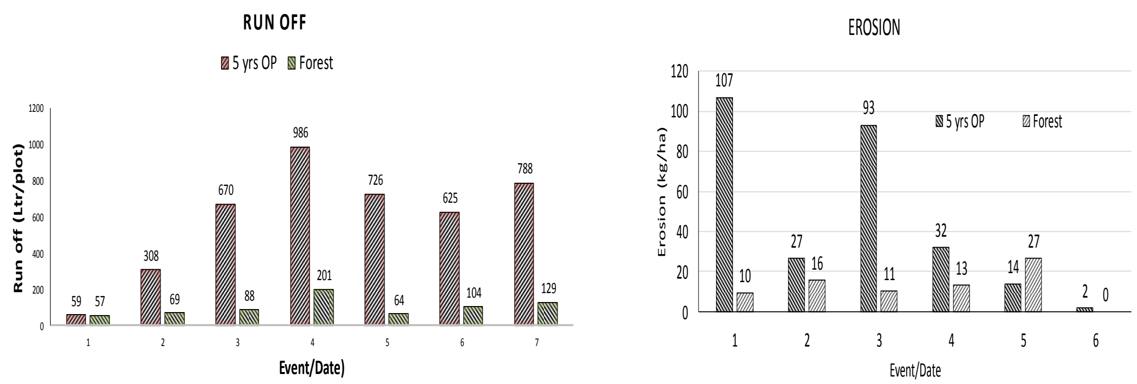

Figure 3. Erosion and surface runoff that occurs in forest areas and 5 years old oil palm plantations

Figure 3, it appears that the level of erosion on 5 years old oil palm plantations was greater than forest areas and this occurs in every event of rain. The average of erosion that occurs in palm oil plantations aged 5 (five) years is 46 kg ha^{-1}, and in forest areas is 13 kg ha^{-1}. The size of the erosion in various rain events was strongly related to the rainfall that occurred on that date, both the amount of rain and the intensity of the rain.

Greater erosion in forest areas was mainly related to canopy cover. In the 5 years old oil palm plantation area, the vegetation canopy was smaller than the cover in the forest area. As many literature states that the amount of erosion was affected by cover vegetation. Tree headings in forest areas have the opportunity to catch (interception) falling rain and reduce the effects of raindrops on the soil which can cause the dispersion effect of soil particles. While on the contrary in the area of oil palm plantations the percentage of canopy cover was lower allowing more raindrops. In addition to the canopy cover, vegetation cover land also affects the amount of erosion that occurs. In the forest area, land cover vegetation in the study area was dominated by low plants and better tree stratification. The cover vegetation causes reduced rainwater dispersion and reduces the amount and velocity of surface runoff so as to reduce erosion (Arsyad, 2000; Arsyad, 2010).

The results of surface runoff calculations that occur in the erosion plot for some rainfall events for forest and 5 year old oil palm plots were presented in Figure 4. Figure 4 it appears that the surface runoff on oil palm plantations was 5 years old, larger than forest areas and this occurs in every event of rain. The average surface runoff that occurred in 5 years of oil palm plantations was 594 L $plot^{-1}$, and the forest area was 102 L $plot^{-1}$.

Rainfall was the cause of surface runoff. If the rain that falls on an area has exceeded the infiltration capacity of the soil, then the excess rainwater will turn into a runoff of water that runoff on the surface (surface runoff). Although in general there was an increase in rainfall followed by an increase in surface runoff, there were several other factors that also influence so that the amount of rainfall cannot be used as the main parameter in determining the amount of surface runoff. Rainfall and initial groundwater factors also affect the amount of surface runoff produced. If the initial ground water level was low, then the rainfall that falls will be more infiltrated into the soil until the field capacity fulfilled, so the amount of water coming out as a surface runoff becomes smaller. This can occur in the event of rain with a low amount of rainfall, where rainfall falls less than the soil infiltration capacity. Conversely, if the rainfall exceeds the infiltration capacity of the soil, the soil will reach saturation faster. This results in only a small part of the falling rain being infiltrated into the soil and the rest will fill the basins on the surface and eventually increase the amount of surface runoff.

Nutrients Lost in Erosion and Surface Runoff

The average analysis results for N, P and K lost in erosion and surface runoff were presented in Tables 1 and 2, respectively. While the calculation of the amount of nutrients N, P and K carried in erosion in each treatment plot respectively presented in Tables 3 and 4.

Table 1. Average results of laboratory analysis for N, P and K nutrients in eroded soils

Date	**Code**	**Total N(%)**	**Total P (ppm)**	**Total K (me/100 g)**
May 12th	P1	0.28	16.20	0.10
	P2	0.17	16.14	0.14
May 22nd	P1	0.18	11.11	0.08
	P2	0.15	10.49	0.06
June 01st	P1	0.30	18.14	0.06
	P2	0.16	10.47	0.05
June 20th	P1	0.21	5.45	0.12
	P2	0.19	10.73	0.05
May 12th	P3	0.20	171.72	0.90
May 22nd	P3	0.33	35.94	0.18
June 01st	P3	0.17	16.30	0.14
June 20th	P3	0.17	16.08	0.08
Minimum	5 years old OP	0.15	5.45	0.05
	Forest	0.17	16.08	0.08
Maximum	5 years old OP	0.30	18.14	0.14
	Forest	0.33	171.72	0.90
Average	5 years old OP	0.21	12.34	0.08
	Forest	0.22	60.01	0.33

Remarks: P1 and P2: 5 years, P3: Forest

Based on Table 2, it appears that the total N content in eroded sediments in 5 years old oil palm plantations ranged from 0.15 to 0.30% with an average of 0.21%, while the Total P ranged between 5, 45-18.14 ppm with an average of 12.34 ppm. For total K content in sediments eroded by 0.05-0.14 me 100 g^{-1} of soil with an average of 0.08 me 100 g^{-1} of soil. For the total N-forest area in eroded sediments on erosion plots ranged from 0.17 to 0.33% with an average of 0.22%, while the Total P ranged from 16.08 to 171.72 ppm with an average amounting to 60.01 ppm. Total nutrient content of K in sediment eroded by 0.08-0.90 me 100 g^{-1} of soil with an average of 0.33 100 g^{-1} soil. Thus the overall content of N, P and K were carried by the soil particles from forest areas was higher than that of 5 years of oil palm areas.

Table 2. Results of laboratory analysis for N, P and K nutrients in surface runoff

Date	Code	Laboratory Results					
		NH_3 (mg l^{-1})	**NO_2 (mg l^{-1})**	**NO_3 (mg l^{-1})**	**N-Total (mg l^{-1})**	**P total (mg l^{-1})**	**K Total (mg l^{-1})**
5 years old oil palm							
May 12th	AP1	0.00	0.01	0.15	0.16	0.03	0.77
	AP2	0.00	0.01	0.03	0.04	0.12	1.22
May 22nd	AP1	0.00	0.01	0.31	0.32	0.03	0.49
	AP2	0.00	0.01	0.01	0.02	0.01	0.74
June 01st	AP1	0.00	0.01	0.13	0.14	0.02	0.36
	AP2	0.00	0.02	0.02	0.04	0.02	1.02
June 20th	AP1	0.27	0.01	0.02	0.30	0.03	0.92
	AP2	0.63	0.01	0.05	0.69	0.05	0.59
July 09th	AP1	0.00	0.09	0.01	0.10	0.05	0.91
	AP2	0.06	0.02	0.02	0.10	0.03	0.7
Forest							
May 12th	AP3	0.00	0.01	0.25	0.26	0.11	1.41
	AP4	0.00	0.02	0.17	0.19	0.24	3.73
May 22nd	AP3	0.00	0.01	0.12	0.13	0.02	0.64
	AP4	0.00	0.01	0.15	0.16	0.04	0.59
June 01st	AP3	0.00	0.01	0.28	0.29	0.04	1.43
	AP4	0.08	0.02	0.01	0.11	0.12	3.66
June 20th	AP3	0.00	0.01	0.01	0.02	0.06	1.77
	AP4	0.12	0.04	0.05	0.21	0.13	4.35
July 09th	AP3	0.00	0.02	0.05	0.07	0.12	4.55
	AP4	0.25	0.01	0.03	0.29	0.06	1.44

Minimum	5 years old OP	0.00	0.01	0.01	0.02	0.01	0.36
	Forest	0.00	0.01	0.01	0.02	0.02	0.59
Maximum	5 years old OP	0.63	0.09	0.31	0.69	0.12	1.22
	Forest	0.25	0.04	0.28	0.29	0.24	4.55
Average	5 years old OP	0.10	0.02	0.08	0.19	0.04	0.77
	Forest	0.05	0.02	0.11	0.17	0.09	2.36

Remarks: P1 and P2: 5 years, P3: Forest, OP= Oil Palam

Based on Table 2, it appears that the total nutrient content of N in surface runoff in 5 year of oil palm plantations ranges from 0.02-0.69 mg L^{-1} with an average of 0.17 mg L^{-1}, with the largest portion in Nitrate (NO_3) form. For total Pl ranges between 0.01-0.12 mg L^{-1} with an average of 0.04 mg L^{-1}. For total K content in surface runoff of 0.36-4.55 mg L^{-1} with an average of 0.77 mg L^{-1}. The total N in forest area in the surface runoff in the erosion plot ranged from 0.22 to 0.29 mg L^{-1} with an average of 0.17%, while the P-total ranged from 0.02 to 0.24 mg L^{-1} with an average of 0.09 mg L^{-1}. Total K content in surface runoff of 0.59-4.55 mg L^{-1} with an average of 2.36 mg L^{-1}. Thus the overall content of N, P and K were carried by surface runoff from forest areas was higher than in 5 years of oil palm areas.

Table 3. N, P and K carried in Erosion in 5 years old oil palm plantation plots and forest areas

Date	Code	N (in erosion) (kg plot^{-1})	P (in erosion) (g plot^{-1})	K (in erosion) (kg plot^{-1})
5 years old oil palm				
May 12th	P1	0.51	29.61	0.07
	P2	0.85	80.67	0.27
May 22nd	P1	0.37	22.77	0.06
	P2	0.87	60.65	0.14
June 01st	P1	0.42	25.41	0.03
	P2	0.30	19.37	0.04
June 20th	P1	0.42	10.90	0.09
	P2	0.57	32.19	0.06
Forest				
May 12th	P3	0.04	32.11	0.07
May 22nd	P3	0.06	6.27	0.01
June 01st	P3	0.08	7.82	0.03

June 20th	P3	0.34	32.16	0.06
Minimum	5 years old OP	0.30	10.90	0.03
	Forest	0.04	6.27	0.01
Maximum	5 years old OP	0.87	80.67	0.27
	Forest	0.34	32.16	0.07
Average	5 years old OP	0.54	35.20	0.10
	Forest	0.13	19.59	0.04

Remarks: P1 and P2: 5 years, P3: Forest, OP: Oil Palm

Based on Table 3, it appears that the total N nutrient content in eroded sediments in 5 years old oil palm plantations ranges from 0.30 to 0.87 kg plot^{-1}, with an average of 0.54 kg plot^{-1}, while the total Pranges from 10.90 to 80.67 g plot^{-1}with an average of 35.20 g plot^{-1}. For total K content in eroded sediments from the research plot of 0.03-0.27 kg plot^{-1} with an average of 0.10 kg plot^{-1}. For the total N in the forest area in eroded sediments on erosion plots ranged from 0.04-0.34 kg plot^{-1}with an average of 0.13 kg plot^{-1}, while the P-total ranged from 6.27-32.16 g plot^{-1}with an average of 19.59 g plot^{-1}. Total K nutrient content in eroded sediments of 0.01-0.07 kg plot^{-1} with an average of 0.04 kg plot^{-1}. Thus, the overall content of N, P and K were carried away from the soil lost in soil erosion from the 5 years old oil palm plantation area, which was higher than in the forest area.

Table 4. N, P and K nutrients carried in the surface runoff in the 5 years old oil palm plantation plot and the forest area

Date	**Code**	**Nutrients in Surface Runoff (mg plot^{-1})**					
		NH_3	**NO_2**	**NO_3**	**N-Total**	**P-Total**	**K-Total**
5 years of oil palm							
May 12th	AP1	0.00	0.50	7.50	8.00	1.50	38.50
	AP2	0.00	0.67	2.01	2.68	8.04	81.74
May 22nd	AP1	0.00	5.80	179.80	185.60	17.40	284.20
	AP2	0.00	7.60	7.60	15.20	7.60	562.40
June 01st	AP1	0.00	9.92	128.96	138.88	19.84	357.12
	AP2	0.00	19.60	19.60	39.20	19.60	999.60
June 20th	AP1	135.00	5.00	10.00	150.00	15.00	460.00
	AP2	472.50	7.50	37.50	517.50	37.50	442.50

July 09th	AP1	0.00	78.75	8.75	87.50	43.75	796.25
	AP2	42.00	14.00	14.00	70.00	21.00	490.00
Forest							
May 12th	AP3	0.00	0.92	23.00	23.92	10.12	129.72
	AP4	0.00	0.42	3.57	3.99	5.04	78.33
May 22nd	AP3	0.00	1.40	16.80	18.20	2.80	89.60
	AP4	0.00	0.35	5.25	5.60	1.40	20.65
June 01st	AP3	0.00	3.60	100.80	104.40	14.40	514.80
	AP4	3.36	0.84	0.42	4.62	5.04	153.72
June 20th	AP3	0.00	2.00	2.00	4.00	12.00	354.00
	AP4	0.96	0.32	0.40	1.68	1.04	34.80
July 09th	AP3	0.00	4.00	10.00	14.00	24.00	910.00
	AP4	14.50	0.58	1.74	16.82	3.48	83.52
Minimum	5 years old OP	0.00	0.50	2.01	2.68	1.50	38.50
	Forest	0.00	0.32	0.40	1.68	1.04	20.65
Maximum	5 years old OP	472.50	78.75	179.80	517.50	43.75	999.60
	Forest	14.50	4.00	100.80	104.40	24.00	910.00
Average	5 years old OP	64.95	14.93	41.57	121.46	19.12	451.23
	Forest	1.88	1.44	16.40	19.72	7.93	236.91

Remarks: P1 and P2: 5 years, P3: Forest, OP= Oil Palm

Based on Table 4, it appears that the total nutrient content of N in surface runoff in 5 years old oil palm plantations ranged from 2.68 to 517.50 mg plot^{-1} with an average of 121.46 mg / plot, with the largest portion in form of ammonium (NH_3). For P-total ranges from 1.50-43.75 mg plot^{-1} with an average of 19.12 mg plot^{-1}. Total K nutrient content in the surface runoff of 0.38.50-999.60 mg plot^{-1} with an average of 451.23 mg plot^{-1}. The N-total nutrient forest area in the surface runoff on erosion plots ranged from 1.68-104.40 mg plot^{-1} with an average of 19.72 mg plot^{-1}, while the P-total ranged from 1.04-24.00 mg plot^{-1} with an average of 7.93 mg plot^{-1}. Total K nutrient content in the surface runoff of 20.65-910.00 mg plot^{-1} with an average of 236.91 mg plot^{-1}. Thus the overall content of N, P and K nutrients carried by the surface runoff from the 5 years old oil palm area was higher than in the forest area. The result from this researh compare to Ariesca (2004) is relatively higher with 393.75 mg/plot (1,050 g/ha) N, 8.13 mg/plot (21,69 g/ha) of P and 406.5 mg/plot (1,084 g/ha) of K were lost from forest area.

Leaching of nutrients on oil palm plantations can be influenced by soil type and rainfall intensity, age of oil palm, agricultural practices, type of fertilizers, water management, and level fertilizer applications. In oil palm plantations that receive chemical fertilizers, loss of nutrients through leaching and concentrations of nutrients in groundwater quality are generally reported to be low. Higher nutrient losses are expected on mature plantations due to lower nutrient uptake by palm roots and higher application of fertilizers is recommended in mature plantations, which can lead to absolute higher losses (Comte, *et al*., 2012). Barnabas *et al*., (2004) found that total loss of between 0.3 and 2.2 kg N/ha.year in Papua New Guinea where this figure lower than the 15–22 kg N/ha.year as reported in Malaysia by Kee and Chew (1996). Kurniawan *et al*. (2018) found that in smallholder oil palm plantation, higher leaching losses of K and other nutirent suc as Na, Ca, Mg and total Al in the fertilized area is higher since the application of inorganic fertilizer and liming.

The results of the study stated by several researchers that watersheds with forest vegetation, NO_3 contributed to a loss of 34% of the loss of nitrogen and DON was the main output of 55%. The loss of NO_3 in a year is lower in the catchment area with native forests compared to catches with plantations where the output of the river discharge exceeds the input of rainfall (Carlos *et al*, 2007).

CONCLUSION AND SUGGESTION

Conclusion

The largest rainfall during the study period occurred in October amounting to 459.5 mm while the smallest occurred in June 2017. The highest number of rainy days took place in November as many as 24 days while the lowest number of rainy days was in May, as many as 7 days. Erosion and runoff on 5 years old oil palm plantations was greater than forest areas and this occurs in every event of rain. The average erosion that occurs in palm oil plantations aged 5 and forest are 46 kg ha^{-1}, and 13 kg ha^{-1}, respectively. The average surface runoff in 5 years palm oil plantations and forest 594 L $plot^{-1}$, and 102 L $plot^{-1}$. The loss of N, P and K content carried away lost in erosion and surface runoff from the 5 years old oil palm plantation area was higher than in the forest area. The total N, P and K loss through eroded sediments both ini 5 years oil palm and forest are higher comper to the loss through runoff water.

Suggestion

Further research needs to be carried out by applying soil and water conservation techniques to oil palm plantations.

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REFERENCES

Ariesca, R.. 2004. Studi Tentang Terjadinya Erosi, Aliran Permukaan, dan Hilangnya Unsur Hara Dalam Aliran Permukaan Pada Lahan hutan Sekunder 1 Tahun BekasTerbakar. Skripsi. Bogor: Depertemen Manajemen Hutan Fakultas Kehutanan Institut Pertanian Bogor. (Online). (http://repository.ipb.ac.id/ bitstream/handle/123456789/ 19012/ E04RAR.pdf?sequence=2, diakses 11 Oktober 2012).

Arsyad, S. 2006. Konservasi Tanah dan Air, Fakultas Pertanian IPB. IPB Press, Cetakan Ke Tiga. Gedung Lembaga Sumberdaya Informasi Lt. 1 Kampus Darmaga, Bogor.

Arsyad, U. 2010. Analisis Erosi Pada Berbagai Tipe Penggunaan Lahan dan Kemiringan Lereng di Daerah Aliran Sungai Jeneberang Hulu. Disertasi Program Pascasarjana Universitas Hasanuddin, UNHAS. Makassar.

Barnabas, M. M. A. Turner, D. R. Scotter, and P. N. Nelson. 2008. C Losses of nitrogen fertiliser under oil palm in Papua New Guinea: 1. Water balance, and nitrogen in soil solution and runoff. Aust.J. Soil Res.46 :332-339.

Breure, K. 2003. The search for yield in oil palm: Basic principles. In “Oil Palm: Management for Large and Sustainable Yields” (T. Fairhurst and R. Hardter, Eds.), pp. 59–98. Potash & Phosphate Institute/Potash Institute of Canada and International Potash Institute, Singapore.

Campiglia E, Mancinelli R, Radicetti E, Marinari S (2010) Legume cover crops and mulches: effects on nitrate leaching and nitrogen input in a pepper crop (Capsicumannuum L.). Nutr. Cycl. Agroecosyst. 89:399-412.

Carlos, O., C. Aracena, P. Rutherford, R. Godoy and An Deschrijver. 2007. Effects of Land Use Conversion from Native Forests to Exotic Plantations on Nitrogen and Phosphorus Retention in Catchments of Southern Chile. *Water Air Soil Pollut* 179:341–350.

Comte, I., J. K. Whalen, O. Grunberger, F. Colin, and J. P. Caliman. 2012. Agricultural Practices in Oil Palm Plantations and Their Impact on Hydrological Changes, Nutrient Fluxes and Water Quality in Indonesia: A Review. In Donald L. Sparks, editor: Advances in Agronomy, Vol. 116 Burlington: Academic Press, 2012, pp. 71-124.

Environment Conservation Department. 2000. Environmental impact assessment (EIA) guidelines on oil palm plantation development. Environmental Conservation Department, Sabah, Malaysia. Available at: http://www.sabah.gov.my/jpas/programs/ecd-cab/technical/OP211100.pdf. (Consulted on Apr 13th, 2011)

Goh, K.J. and Chew, P.S. 1995. Managing soils for plantation tree crops. 1. General soil management. In “Course on Soil Survey and Managing Tropical Soils” (S. Paramanathan, Ed.), pp. 228–245. MSSS and PASS, Kuala Lampur.

Goh, K.J., Härdter, R. and Fairhurst, T. 2003. Fertilizing for maximum return. In: Fairhurst T, Hardter R (eds) Oil Palm: Management for Large and Sustainable Yie. Potash & Phosphate Institute/Potash & Phosphate Institute of Canada and International Potash Institute (PPI/PPIC and IPI, Singapore, pp 279–306.

Indonesian Ministry of Agriculture. 2010. Area and production by category of producers: palm oil, Direktor at Jenderal Perkebunan. KementerianPertanian. Availableat: http://ditjenbun.deptan.go.id/index.php/direktori/3-isi/4-kelapa-sawit.html. (Consultedon April 13th, 2011)

Kartasapoetra, A. G. 1986. Pengaruh Iklim Terhadap Tanah dan Tanaman. Jakarta:Bumi Aksara.

Kartasapoetra, A. G., and S.M.Mulyani. 2003. Teknologi Konservasi Tanah & Air. Jakarta: Rineke Cipta.

Kee, K. K., and Chew, P. S. (1996). Nutrient losses through surface runoff and soil erosion—Implications for improved fertilizer efficiency in mature oil palms. In “Proceedings of the PORIM Internation Palm Oil Congress” (A. Ariffin, M. B. Wahid, N. Rajanaidu, D.

Tayeb, K. Paranjothy, S. C. Cheah, K. C. Chang, and S. Ravigadevi, Eds.), pp. 153–169. Palm Oil Research Institute of Malaysia, Kuala Lampur.

Kundarto. 2005. Neraca air, Erosi tanah dan Traspor Lateral Hara NPK Pada Sistem Persawahan di Sub DAS Kali Babon, Semarang.http://www.google.co.id/ur.balittanah.litbang.deptan.go.id%2Fdokumentasi%2Fprosiding%2Fmflp2003%2Fkundarto17. [4 Juli 2011]. Lembaga Sumberdaya, IPB. Bogor Press.

Kurniawan, S., M. D. Corre, S. R. Utami and E. Veldkamp. 2018. Soil Biochemical Properties and Nutrient Leaching from Smallholder Oil Palm Plantations, Sumatra-Indonesia. AGRIVITA J. of Agric.Sci. 40 : 257-266

Nykvist, N. Grip, H., Liang Sim, B., Malmers, A. and Khiong Wong, F. 1994. Nutrient Losses in Forest Plantations in Sabah, Malaysia. *Ambio* Vol. 23, No. 3 : 210-215.

Sheil, D., Casson, A., Maijaard, E., van Noordwijk, M., Gaskell, J., Sunderland Groves, J., Wertz, K., and Kanninen, M. 2009. The impacts and opportunities of oil palm in Southeast Asia. Center for International Forestry Research, Bogor.

Susanti, A. and Burgers, P.P.M. 2012. Oil palm expansion in Riau province, Indonesia: serving people, planet, profit? Background Paper to the 2011/2012 European Report on Development: Confronting Scarcity: Managing Water, Energy and Land for Inclusive and Sustainable Growth. European Union, Brussels. Available at : http://erd-report.eu/erd/report_2011/documents/researchpapers_susanti-burgers.pdf (Consulted on January 27th, 2015)

Susila, W.R. 2004. Contribution of Oil Palm Industry to Economic Growth and Poverty Alleviation in Indonesia. Jurnal Litbang Pertanian, 23(3): 107-114.

Vitousek, P. M., Aber, J. D., Howarth, R. W., Likens, G. E., Matson, P. A., Schindler, D. W., et al. (1997). Technical report: Human alteration of the global nitrogen cycle: Sources and consequences. Ecological Applications, 7(3), 737–750.

Conversion of forest to oil palm plantation and its impact to erosion and surface runoff on from in Jalemu watershed, Central Kalimantan Province

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Abstract. Changes in land cover from forest areas to non-forest areas are believed to affect hydrological conditions and water quality in watershed ecosystems, one of which is conversion to oil palm plantations. Increased production and area of oil palm plantations have an impact on the environment and damage to waters caused by oil palm plantations, and has become one of the environmental issues. Research is conducted to provide an overview of erosion and surface runoff from oil palm plantations and forest using plots of 15m x 25m each made in the Jalemu Watershed, Gunung Mas District, Central Kalimantan Province, which covers the area of oil palm and forest plantations, to study the impact of changes in land cover on the level of erosion and runoff and nutrients that are lost in both processes that will flow to the Jalemu watershed. Sediment and water sampling is carried out from erosion reservoir and surface runoff, and analysis of N, P and K nutrients in sediments and surface runoff water is carried out. The results showed that the highest erosion and surface runoff that occurred in the oil palm area were 5 years followed by 3 years of oil palm plantations and forest areas and this also had implications for the loss of nutrients from the oil palm plantation area and brought a number of nutrients and potential water pollution by these nutrients and it is found that in all the land cover most of the nutrients are lost along with the sediment, and only a small portion in the water surface flow.

INTRODUCTION

Production of palm oil (*Elaeis guineensis*) has grown rapidly in the tropics over the past decade. As the world's largest palm oil producer since 2007, the Indonesian Government plans to increase production to 40 million tons of coconut crude by 2020, mainly in Sumatra, Kalimantan and West Papua [1]. Riau Province in Central Sumatra is the largest producer of palm oil in Indonesia, accounting for around 24% of the total national production. From 2004 to 2009, the area of oil palm in Riau Province increased by 21% [1], [2], and in its development the region of Central Kalimantan also increased the area of oil palm cultivation and production. The development of the area of oil palm plantations in particular in Central Kalimantan is quite large, so also the increase in production has increased very rapidly. Palm oil is one of the industries that is the backbone of Indonesia economy and also provides the largest contribution to non-oil and gas exports in Indonesia [3]. Rapid expansion such as the palm oil industry shows that extraordinary land use changes are taking place in Indonesia, which raises concern for the environment and human health.

Various environmental issues continue to occur in relation to the development of oil palm plantations, including issues related to water conditions in the region and water quality. Regarding the deterioration of the water crisis in various regions, some people have accused that oil palm-based companies have a lot to contribute to the waste of water discharge to run their plantations. Issues concerning disruption to regional water management caused by the development of oil palm have emerged as environmental issues. Oil palm plantations are considered to be the cause of reduced availability of ground water and can have an impact on decreasing groundwater levels. These challenges are feared to affect the level of productivity and export volume of palm oil and its derivative production. In addition, it will always be used as an issue that increasingly pressure to oil palm plantations and derivative products. The issue of greedy oil palm plantations being one of the environmental issues as the impact of oil palm plantations in an area, but there is no data to support these accusations. Along with the erosion and surface flow that occurs from oil palm plantations, there are indications that it will lead to a change in water quality in the aquatic ecosystem around the location of oil palm plantations related to nutrients both dissolved and transported in the sediment. Provisional allegations that water loss and disruption of the water system in an area are caused more by the loss of water storage function on plantation land and not by consumption of oil palm plants.

Most activities related to the development of oil palm plantations and exploitation (eg forest clearing, road construction and drainage networks, use of agricultural chemicals and the release of wastewater) present risks to land surface and groundwater quality [4] [5]. Hydrological conditions and aquatic ecosystems close to plantations are very risky for decreasing water quality because fertilization is applied on plantations at a relatively high level [6]. Runoff and drainage water from oil palm plantations is controlled by cover crops planted legumes. However, the understorey is disappearing due to the closed canopy of the oil palm plant, with vegetation cover to maintain excess water and nutrient-rich sediments. Furthermore, the decomposition of the cover crop legume under the adult canopy releases nitrogen that previously occurred through nitrogen fixation [5][7][8]. It is asserted that the nitrate loss of leaching from legume plants was influenced by soil texture and greater recorded losses in sandy soils [9]. Conversion of land use, especially from forests to agricultural or grassland land, greatly influences nutrient fluxes in the watershed [10]. The effect of converting forests to plantations on nitrogen and phosphorus is completely not well understood. Vegetation substitution by logging practices might have an impact on river water quality through loss of biomass, variable amounts of slash logging on forest floor, accelerated soil erosion and N mineralization [11].

Therefore, it is necessary to carry out research to study the magnitude of erosion and surface run off in the watershed area that covers the area of oil palm plantations. From the results of this study, a portion will be answered which causes the potential damage caused by land degradation in a watershed area.

RESEARCH METHOD

The research was conducted on forest land and oil palm plantations owned by PT. KHS included in the Jalemu Watershed, Manuhing Subdistrict, Gunung Mas Regency as presented in Figure 1. The study was conducted for 4 months consisting of 2 stages, namely field data collection in the June-September 2017 for erosion and runoff measurement as well as sediment and water analysis in Analytical Laboratory, The University of Palangka Raya.

This research was conducted in the field with three land cover factors and two replications. Plots for forest land use and oil palm plantations aged 3 and 5 years. Erosion plots were made at each landcover with a size of 15m x 25m with each side of the map mounted plate with a height of 20 cm above the ground surface. The erosion and surface runoff collection box and used are made with the size of 5m x 0.5m x 0.5m, and on the side facing out there are 7 holes with a diameter of 2.5 inches. The middle hole is connected by a 2.5 inch pipe to B box (Figure 2). Measurement of erosion and surface run off is carried out following each rainfall event during the study. The amount of soil and sediment (E) is carried out by wet weighing in the field. Sediment samples were taken to determine moisture content by drying in an oven at 105 ºC for 24 hours. For the volume of surface flow determined in the field and sampling is also carried out to analyze the nutrient content in the surface runoff. Data collected were analized by using descriptive analysis to compare of each factor.

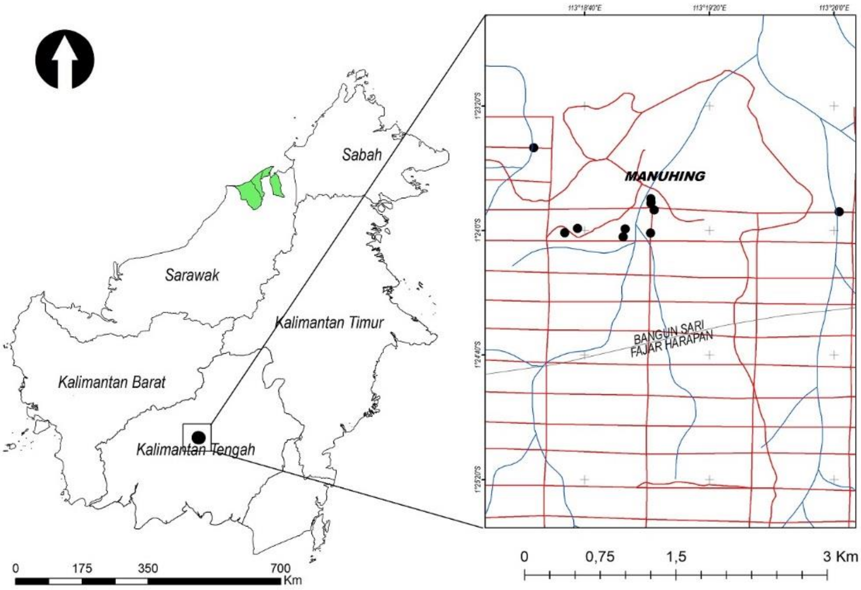


Figure 1. Map of research location in Jalemu Watershed which mainly dominated by oil palm plantation

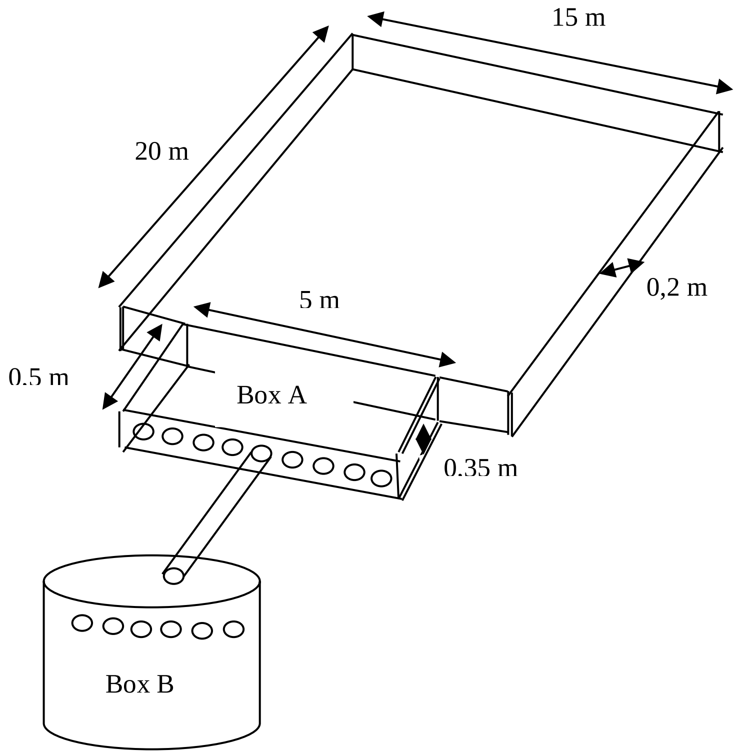


Figure 2. Collection box for erosion and runoff

Analysis of water and sediment was carried out at the Analytical Laboratory, Palangka Raya University, including the concentration of Total N (Kjeldhal), Total P (Bray I with spectrophotometer), and Total K (NH_4OAc pH 7.0 with a photometer flame). Water analysis includes NH_3 (Kjedhal), NO_2 (Sulfanilamide) and NO_3 (Colorimetric) and P (Spectrophotometer) and K (Atomic Adsorption Spectrophotometer, AAS). The results of the Total N, P and K analysis through erosion or surface run off are calculated by the following equation:

$$X = Y \times E$$

where:

X = N, P and K losses due to erosion or surface run off (kg ha^{-1})

Y = Total N (%), P (ppm) and K (me $100gr^{-1}$ soil) concentrations in sediment or in surface runoff (mg L^{-1})

E = Total soil erosion (kg ha^{-1}) or volume of surface runoff (L)

RESULTS AND DISCUSSIONS

1. Rainfall

Rainfall data recorded using an ombrometer tipping bucket type during research and processing results in monthly rainfall are presented in Figure 3. Observations show 117 rainy days observed in the period May 2017 to February 2018.

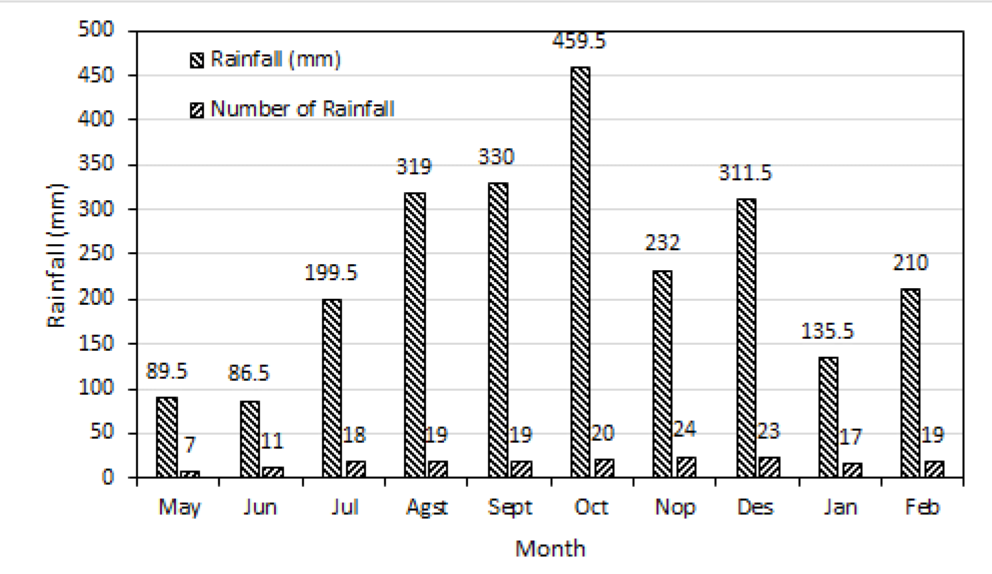
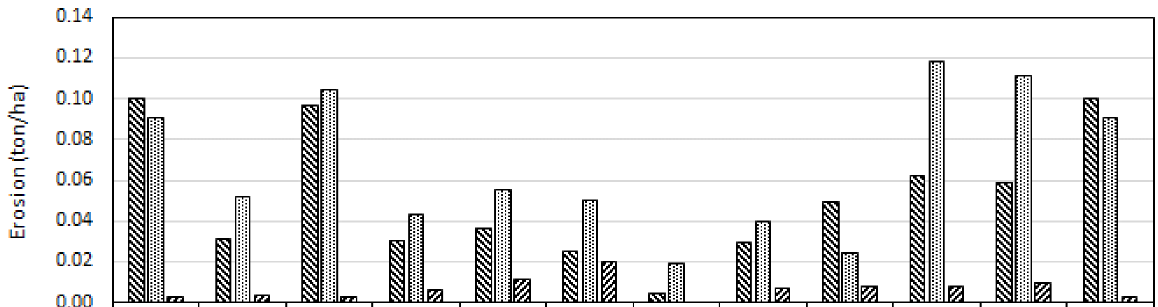


Figure 3. Amount of rainfall and number rainy day at the research location.

Figure 3 shows the pattern of decreasing rainfall in each treatment in the dry season period, namely in May and June. The largest rainfall during the study period occurred in October 2017 (459.5 mm), while the smallest occurred in June 2017 (86.5mm). The highest number of rainy days takes place in November, which is 24 days, while the lowest number of rainy days is in May, which is 7 days. Rain is one of the important factors that influence erosion and surface runoff and is the beginning of the cause of erosion in the presence of energy which has an effect on soil dispersion. The destruction of the soil particle and the destructive power of the surface run off caused by rain is very significant to erosion. Rain is a part of climate factors that play a role in controlling surface runoff and erosion. Some of the characteristics of rain that affect the volume of the surface runoff are the type of rainfall, the intensity of the rainfall, the length of the rainfall, the distribution of rainfall, and the direction of rainfall [12]. The effect of rainfall intensity has a relationship that is directly proportional to the volume and flow rate of the surface runoff. In general, there is a tendency to increase the amount of surface runoof with increasing rainfall intensity, but this also depends on the soil infiltration capacity. If the rain intensity exceeds the soil infiltration capacity, there will be an increase in the amount of surface runoff in line with the increase in the intensity of the rainfall. The length of rainfall factor also influences the amount of surface runoff [13]. The longer the rainfalls, the greater the surface runoff that occurs, although this depends on the intensity and the amount of rainfall.

2. Erosion

The results of erosion calculations that occur for some rainfall events for both forest areas and 3 and 5 year old oil palm plantations are presented in Figure 4.



	12-May	17-May	22-May	1-Jun	12-Jun	20-Jun	9-Jul	6-Sep	30-Sep	11-Oct	31-Oct	Avg
OP 3 Yrs	0.10	0.03	0.10	0.03	0.04	0.03	0.00	0.03	0.05	0.06	0.06	0.10
OP 5 Yrs	0.09	0.05	0.10	0.04	0.06	0.05	0.02	0.04	0.02	0.12	0.11	0.09
Forest	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.01	0.01	0.01	0.01	0.002

Date

Figure 4. Erosion that occurs in forest areas and oil palm plantations aged 3 years and 5 years

From Figure 4 it appears that the erosion in 3-year-old oil palm plantations is greater than 5 years of oil palm and then followed by the erosion value of the forest area and this occurs in most rainfall events. The average erosion that occurred in 3-year-old oil palm plantations was 0.10 tons ha^{-1}, 5years was 0.09 tons ha^{-1}, and in the forest area was 0.002 tons ha^{-1}. The size of the erosion in various rain events is strongly related to the rainfall that occurred on that date, both the amount of rain and the intensity of the rain. One factor that influences the amount of erosion is crop canopy cover. In the 3-year and 5-year-old oil palm plantation areas, the vegetation canopy is smaller than the cover in the forest area. As many references state that the amount of erosion is affected by cover vegetation. Tree headings in forest areas have the opportunity to catch (*interception*) falling rain and reduce the effects of raindrops on the soil which can cause the dispersion effect of soil particles. While on the contrary in the area of oil palm plantations the percentage of canopy cover is lower allowing more thrrough fall.

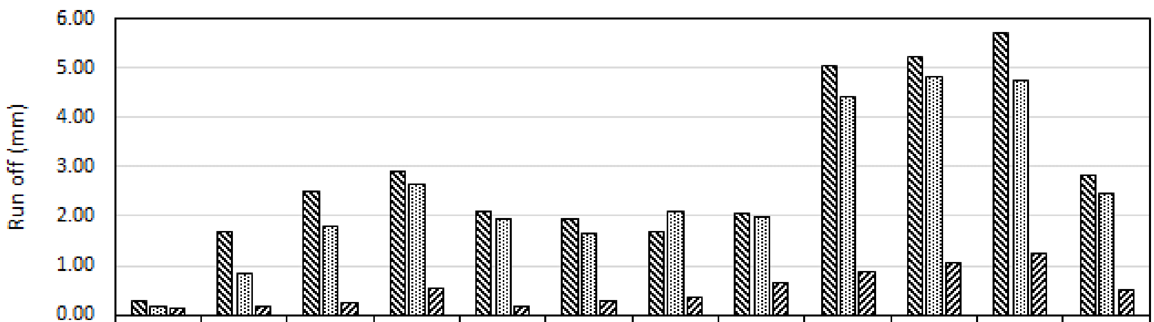
Plants that have fibrous roots like oil palm plants, are more effective in controlling the process of erosion, this is because the fine threads on the fiber roots are able to bind the soil particles into a solid aggregate of soil. The growth phase (age) of the plant also has a different effect on the erosion control process. At the beginning, the growth of canopy cover plants is still relatively open, causing rainwater to fall directly to the soil surface. This can accelerate the occurrence of surface flow because of the chance that the water to be infiltrated into the soil is low. Plant height also plays a role in increasing the effectiveness of cover crops in reducing erosion. The lower the canopy and the tighter the canopy of the plant, the smaller the energy of the rain that reaches the surface of the soil [14]. In addtion that vegetation can affect erosion due to: (1) interception of rainfall by canopy and absorption of rainwater energy so as to minimize soil erosivity, (2) influence on surface runoff, (3) increase in soil biological activity, and (4) increase speed of water loss through transpiration [15].

The effect of vegetation factors on the magnitude of erosion that occurs can be seen from the level of crop canopy cover and vegetation cover in the forest and oil palm plantations. Oil palm plantations in the study area are plants that are 5-6 years old with relatively close levels of canopy cover compared to younger oil palms, but are still more open than forests. This can be seen from the distance between the canopy from one plant to another plant close enough. Relatively close canopy cover levels cause falling rain to be more retained by plant canopy. In addition to being held back by the canopy of fallen rain plants can also flow through the flow of stems which will then be forwarded to the soil surface with relatively small strength. The reduced energy of rainfall that reach the surface of the soil will result in reduced ability of raindrops to disperse the soil so that it can reduce the amount of erosion that occurs. In forest areas, the presence of canopy stratification also affects the decreasing effects of raindrops and surface runoff, which in turn can reduce erosion.

In addition to the canopy cover, vegetation cover land also affects the amount of erosion that occurs. In the forest area, land cover vegetation in the study area is dominated by low plants and better tree stratification. The cover vegetation causes reduced rainwater dispersion and reduces the amount and velocity of surface flow so as to reduce erosion [14].

3. Surface runoff

The results of the calculation of surface runoff that occurs in several rainfall events for both forest areas and oil palm plantations aged 3 and 5 years are presented in Figure 5.



	12-May	17-May	22-May	1-Jun	12-Jun	20-Jun	9-Jul	6-Sep	30-Sep	11-Oct	31-Oct	Avg
OP 3 Yrs	0.27	1.70	2.50	2.90	2.09	1.93	1.69	2.07	5.03	5.21	5.69	2.83
OP 5 Yrs	0.16	0.82	1.79	2.63	1.94	1.67	2.10	1.97	4.41	4.83	4.77	2.46
Forest	0.15	0.18	0.23	0.54	0.17	0.28	0.34	0.64	0.86	1.04	1.23	0.52

Date

Figure 5. Surface runoff that occurs in forest areas and oil palm plantations aged 3 and 5 years

From Figure 5 it appears that the surface runoff on a 3-year-old oil palm plantation is greater than a 5-year-old palm, and is followed from a forest area and this occurs in most rain events. The average surface runoff that occurred in 3-years palm oil plantations was 2.83 mm followed by 5 years palm oil at 2.46 mm and 0.52 mm in forest area. Rainfall is the cause of the occurrence of surface runoff, if the rain that falls on an area has exceeded the infiltration capacity of the soil then the excess rainwater will turn into a stream of water that flows on the surface (surface runoff). Although in general there is an increase in rainfall followed by an increase in surface runoff, there are several other factors that also influence so that the amount of rainfall cannot be used as the main parameter in determining the amount of surface runoff. Rainfall and initial groundwater factors also affect the amount of surface runoff produced. If the initial ground water level is low, then the rainfall that falls will be more infiltrated into the soil until the field capacity is fulfilled, so the amount of water coming out as a surface runoff becomes smaller. This can occur in the event of rain with a low amount of rainfall, where rainfall falls less than the soil infiltration capacity. Conversely, if the rainfall exceeds the infiltration capacity of the soil, the soil will reach saturation faster. This results in only a small part of the falling rain being infiltrated into the soil and the rest will fill the basins on the surface and eventually increase the amount of surface flow.

4. Nutrients are losses in erosion and runoff

The average results of laboratory analysis for N, P and K losses in erosion and surface run off are presented in Tables 1 and 2 respectively. While the calculation of the amount of nutrients N, P and K carried in erosion in each treatment plot each is presented in Figure 6-11.

Table 1. Average results of laboratory analysis for N, P and K in eroded soils

	Land cover	N-Total (%)	P total (ppm)	K-Total (me/100 g)
Minimum	Oil Palm 3 yrs	0.16	10.09	0.03
	Oil Palm 5 yrs	0.15	5.45	0.05
	Forests	0.17	16.08	0.08
Maximum	Oil Palm 3 yrs	0.23	29.39	0.19
	Oil Palm 5 yrs	0.30	18.14	0.14
	Forests	0.33	171.72	0.90
Average	Oil Palm 3 yrs	0.19	19.63	0.09
	Oil Palm 5 yrs	0.21	12.34	0.08
	Forests	0.22	60.01	0.33

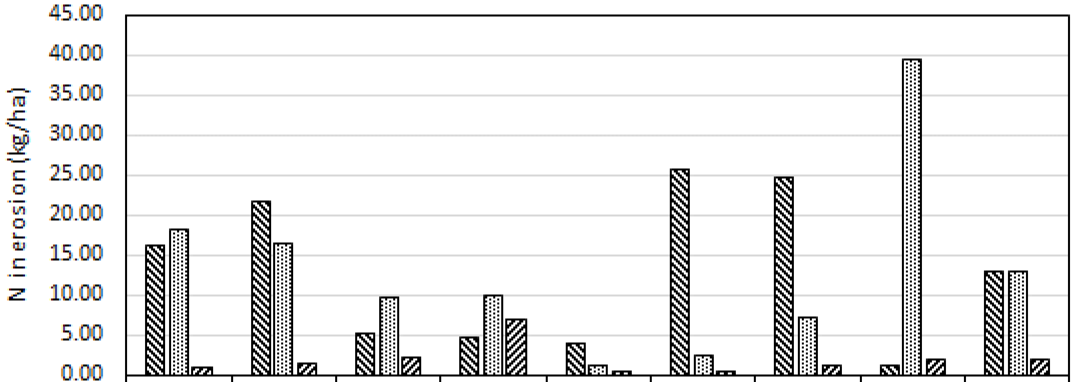
Based on Table 1, it appears that the total N content in eroded sediments in 3-year-old oil palm plantations ranged between 0.16-0.23% and an average of 0.19% and for 5 years ranged between 0.15-0.30% with an average of 0.21%, while in the forest area ranged between 0.17-0.33% and an average of 0.22%. P-total ranges from 10.09-29.39 ppm and an average of 19.63ppm (3 years oil palm); 5.45-18.14 ppm with an average of 12.34 ppm (5 years oil palm) and 16.08-171.72 ppm and an average of 60.01 ppm P (forest). For total K content in eroded sediments of 0.03-0.19 me $100g^{-1}$ soil and an average of 0.09 me $100g^{-1}$ soil (3 years oil palm); 0.05-0.14 me $100g^{-1}$ soil with an average of 0.08 me $100g^{-1}$ soil (5 years oil palm); 0.08-0.90 me $100g^{-1}$ of soil and an average of 0.33 me $100g^{-1}$ of soil (forest). Thus, overall the content of N, P and K associated with soil particles from forest areas is higher than in oil palm areas that are 3 and 5 years old.

Table 2. Average results of laboratory analysis for N, P and K in surface runoff

	Land cover	NH_3 (mg L^{-1})	NO_2 (mg L^{-1})	NO_3 (mg L^{-1})	N-Total (mg L^{-1})	P total (mg L^{-1})	K Total (mg L^{-1})
Minimum	Oil Palm 3 yrs	0,00	0,01	0,01	0,02	0,02	0,01
	Oil Palm 5 yrs	0,00	0,01	0,01	0,02	0,01	0,36
	Forests	0,00	0,01	0,01	0,02	0,02	0,59
Maximum	Oil Palm 3 yrs	0,49	0,02	0,85	0,86	22,57	4,18
	Oil Palm 5 yrs	0,63	0,09	0,31	0,69	0,12	1,22
	Forests	0,25	0,04	0,28	0,29	0,24	4,55
Average	Oil Palm 3 yrs	0,08	0,01	0,22	0,31	3,71	1,02
	Oil Palm 5 yrs	0,10	0,02	0,08	0,19	0,04	0,77
	Forests	0,05	0,02	0,11	0,17	0,09	2,36

Based on Table 2, it appears that the total nutrient content of N in surface runoff in 3-year-old oil palm plots is between 0.02-0.86 mg L^{-1} and an average of 0.31 mg L^{-1}; 0.02-0.69 mg L^{-1} with an average of 0.19 mg L^{-1} (5 years oil palm) with the largest portion in the form of ammonia (NH_3), between 0.02-

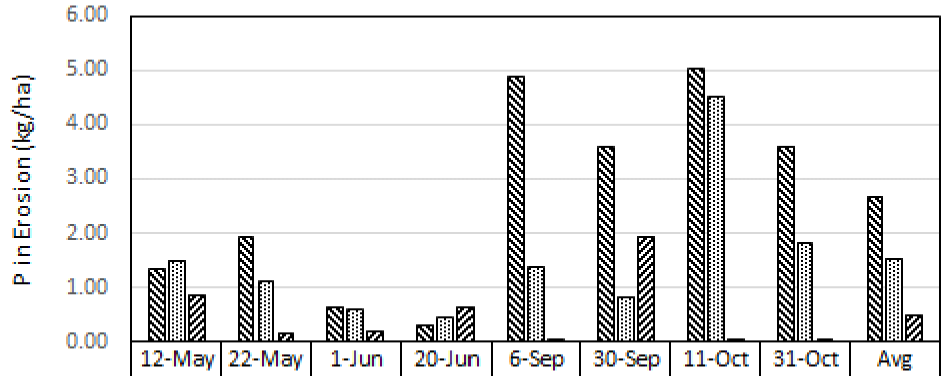
0.29 mg L^{-1} and on average 0.17mg L^{-1} (forest). For P-total ranges from 0.02-22.57mg L^{-1} and an average of 0.04 mg L^{-1} (3 years oil palm); 0.01-0.12 mg L^{-1} with an average of 0.04 mg L^{-1} (5 years oil palm); 0-02-0.24 mg L^{-1} and an average of 0.09 mg L^{-1} (forest). For total K nutrient content in the surface runoff of 0.01-4.18 mg L^{-1} and an average of 1.02 mg L^{-1} (3 years oil palm); 0.36-1.22 mg L^{-1} with an average of 0.77 mg L^{-1} (5 years oil palm); 0.59-4.55 mg L^{-1} and an average of 2.36 mg L^{-1} (forest). Thus in general the nutrient content of N, P and K which is carried by surface runoff from forest areas is higher than in oil palm areas that are 3 and 5 years old.



	12-May	22-May	1-Jun	20-Jun	6-Sep	30-Sep	11-Oct	31-Oct	Avg
OP 3 Yrs	16.09	21.78	5.29	4.65	3.97	25.60	24.62	1.16	12.90
OP 5 Yrs	18.15	16.48	9.55	9.90	1.19	2.35	7.19	39.48	13.04
Forest	1.00	1.53	2.18	6.80	0.42	0.47	1.14	1.94	1.93

Figure 6. N in Erosion on 3 and 5 year old oil palm plots and forest areas

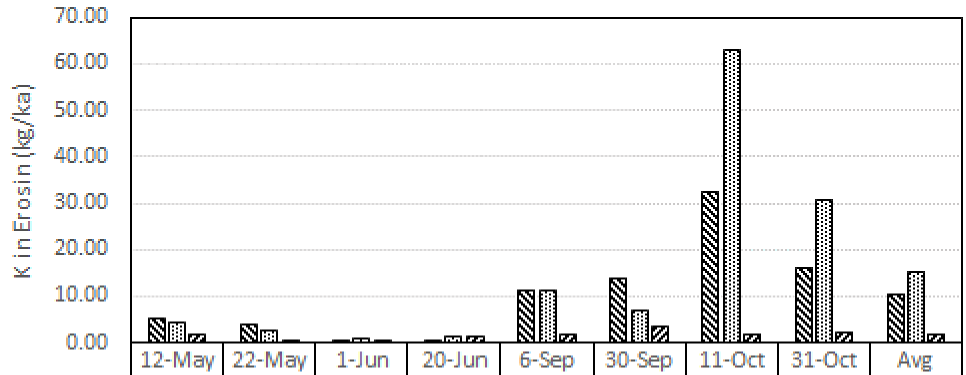
Nutrient concentrations in sediment eroded and the amount of erosion determines the amount of nutrients losts in erosion and the amount of nutrient loss for N, P and K is presented in Figures 8, 9 and 10. Based on Figure 6, it appears that the total N content in sediment eroded in the plot of 3-year-old oil palm plantations ranging from 1.16-35 kg ha^{-1} (an average of 12.90 kg ha^{-1}) and for 5-year palm oil ranging from 1.19 to 39.48 kg ha^{-1} (an average of 13.04 kg ha^{-1}) and forests between 0.42-6.80 kg ha^{-1} (an average of 1.93 kg ha^{-1}). In Figure 7, it appears that the loss of P-total in erosion in 3-year palm oil ranged from 0.30 to 5.01 kg ha^{-1} (an average of 2.65 kg ha^{-1}), followed by 5-year oil palm from 0.43 to 4.51 kg/ha (average 1.52 kg ha^{-1}) and forest between 0.03-1.91 kg ha^{-1} (average 0.49 kg ha^{-1}). For total K content in eroded sediments as shown in Figure 8, from the research plot on 5-year palm oil K-loss with a range between 0.92-62.82 kg ha^{-1} (average 15.17 kg ha^{-1}) followed by 3-year palm oil between 0.45-32.38 kg ha^{-1} (an average of 10.46 kg ha^{-1}) and forest of 0.33-3.42 kg ha^{-1} (an average of 1.61 kg ha^{-1}). Thus, the overall content of N, P and K carried away from the soil in soil erosion from oil palm plantations is 3 and 5 years higher than in forest areas.



	12-May	22-May	1-Jun	20-Jun	6-Sep	30-Sep	11-Oct	31-Oct	Avg
OP 3 Yrs	1.35	1.91	0.63	0.30	4.88	3.59	5.01	3.57	2.65
OP 5 Yrs	1.47	1.11	0.60	0.43	1.39	0.83	4.51	1.81	1.52
Forest	0.86	0.17	0.21	0.64	0.06	1.91	0.03	0.04	0.49

Date

Figure 7. P in Erosion on 3 and 5-year old oil palm plots and forest areas

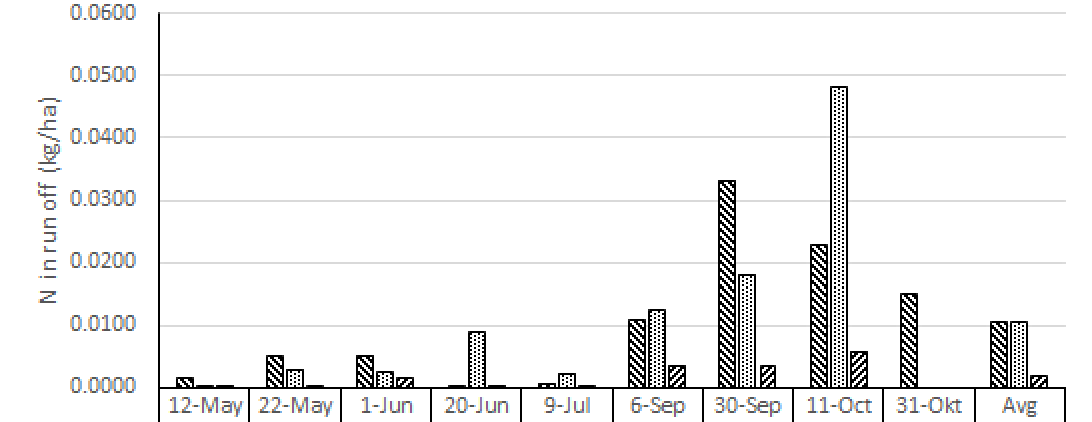


	12-May	22-May	1-Jun	20-Jun	6-Sep	30-Sep	11-Oct	31-Oct	Avg
OP 3 Yrs	5.19	3.86	0.65	0.45	11.12	13.99	32.38	16.07	10.46
OP 5 Yrs	4.59	2.66	0.92	1.52	11.47	6.85	62.82	30.54	15.17
Forest	1.75	0.33	0.70	1.25	1.60	3.42	1.75	2.05	1.61

Date

Figure 8. K in Erosion on 3 and 5 year old oil palm plots and forest areas

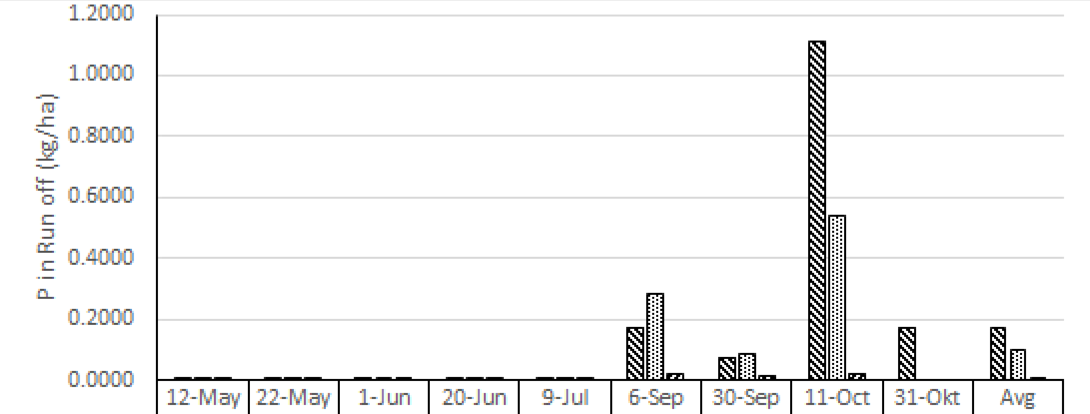
Nutrients losses through surface runoff are a combination of surface runoff volume and nutrient content in the surface runoff. Based on Figure 9, it appears that the total N in surface runoff in 3-year-old oil palm plantations ranged from 0.004 to 0.0332 kg ha^{-1} (an average of 0.0105 kg ha^{-1}) followed by oil palm 5 years ranging between 0-0.481 kg ha^{-1} (average 0.0105 kg ha^{-1}) and forests between 0-0.0058 kg ha^{-1} (average 0.0017 kg ha^{-1}), with the largest portion in the form of ammonia (NH_3). For P-total (Figure 10) the losses ranged from 0,0002-1,1105 kg ha^{-1} (average 0.1691 kg ha^{-1}) for 3-year-old palm oil followed by 5-year palm oil between 0-0.5420 kg ha^{-1} (average 0.1016 kg ha^{-1}) and forests between 0-0.0174 kg ha^{-1} (average 0.0058 kg ha^{-1}).



	12-May	22-May	1-Jun	20-Jun	9-Jul	6-Sep	30-Sep	11-Oct	31-Okt	Avg
OP 3 Yrs	0.0015	0.0052	0.0051	0.0004	0.0006	0.0110	0.0332	0.0227	0.0151	0.0105
OP 5 Yrs	0.0001	0.0027	0.0024	0.0089	0.0021	0.0127	0.0179	0.0481	0	0.0105
Forest	0.0004	0.0003	0.0015	0.0001	0.0004	0.0036	0.0034	0.0058	0	0.0017

Date

Figure 9. N in the surface runoff of 3 and 5 year old oil palm plots and forest areas

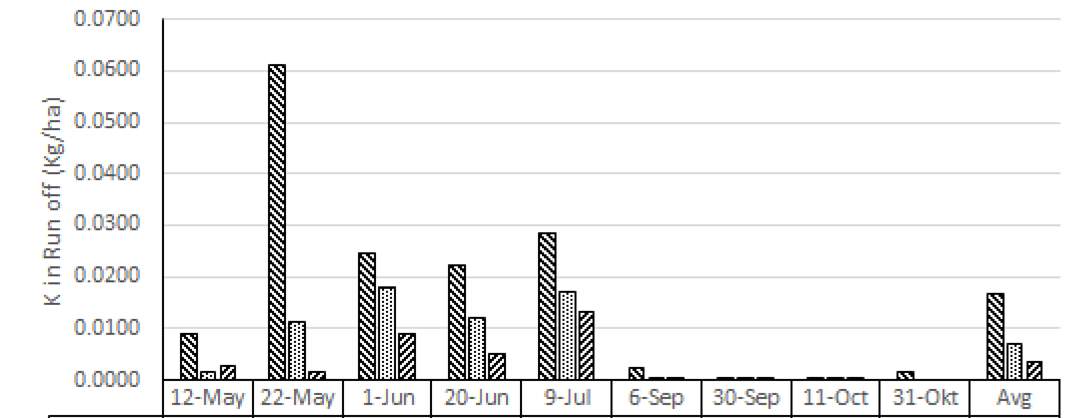


	12-May	22-May	1-Jun	20-Jun	9-Jul	6-Sep	30-Sep	11-Oct	31-Okt	Avg
OP 3 Yrs	0.0002	0.0005	0.0007	0.0005	0.0007	0.1704	0.0703	1.1105	0.1681	0.1691
OP 5 Yrs	0.0001	0.0003	0.0005	0.0007	0.0009	0.2822	0.0876	0.5420	0	0.1016
Forest	0.0002	0.0001	0.0003	0.0002	0.0004	0.0174	0.0132	0.0208	0	0.0058

Date

Figure 10. P in the surface runoff in 3 and 5 year old oil palm plots and forest areas

For total K content in surface runoff (Figure 11) in the 3-year oil palm plantation plot of 0.0005-0.0610 kg ha^{-1} (average 0.0167 kg ha^{-1}) followed by 5-year-old oil palm plantation, which is 0-0.0181 kg ha^{-1} (average 0.0068 kg ha^{-1}) and forests between 0-0.0132 kg ha^{-1} (average 0.0036 kg ha^{-1}). Thus, the overall content of N, P and K carried by the surface runoff from the 3-year-old palm oil area is higher than the 5-year palm and is followed in the forest area.



	12-May	22-May	1-Jun	20-Jun	9-Jul	6-Sep	30-Sep	11-Oct	31-Okt	Avg
OP 3 Yrs	0.0089	0.0610	0.0246	0.0222	0.0283	0.0022	0.0005	0.0005	0.0017	0.0167
OP 5 Yrs	0.0016	0.0113	0.0181	0.0120	0.0172	0.0004	0.0006	0.0005	0	0.0068
Forest	0.0028	0.0015	0.0089	0.0052	0.0132	0.0001	0.0005	0.0005	0	0.0036

Figure 11. K in surface runoff in 3 and 5 year old oil palm plots and forest areas

The results of the study stated by several researchers that watersheds with forest vegetation, NO_3 contributed to a loss of 34% of the loss of nitrogen and DON was the main output of 55%. The loss of NO_3 in a year is lower in the catchment area with native forests compared to catches with plantations where the output of the river discharge exceeds the input of rainfall [16]. Leaching of nutrients on oil palm plantations can be influenced by soil type and rainfall intensity, age of oil palm, agricultural practices, type of fertilizers, water management, and level fertilizer applications. In oil palm plantations that receive chemical fertilizers, loss of nutrients through leaching and concentrations of nutrients in groundwater quality are generally reported to be low. Higher nutrient losses are expected on mature plantations due to lower nutrient uptake by palm roots and higher application of fertilizers is recommended in mature plantations, which can lead to absolute higher losses [17]. The result from this research compare to Ariesca [18] is relatively higher with 1,050 g/ha) N; 21.69 g/ha of P and 1,084 g/ha of K were lost from forest area. Furthermore, it is found that total loss of between 0.3 and 2.2 kg N/ha.year in Papua New Guinea [19] where this figure lower than the 15–22 kg N/ha.year as reported in Malaysia [20]. A higher leaching losses of K and other nutirent such as Na, Ca, Mg and total Al in the fertilized area is higher in smallholder oil palm plantation, since the application of inorganic fertilizer and liming [21].

CONCULSION AND SUGGESTIONS

Conclusion

1. The highest rainfall during the study period occurred in October (459.5 mm) while the lowest occurred in June 2017. The highest number of rainy days took place in November (24 days) while the lowest number of rainy days was in May (7 days).
2. Erosion and runoff on oil palm plantations aged 3 years and 5 years is greater than forest areas and this occurs in most rainfall events. The average erosion that occurred in the 3-year-old palm oil plantation was 0.10 tons ha^{-1} and 5 years was 0.09 tons ha^{-1}, and in the forest area was 0.002 tons ha^{-1}. The average surface run off that occurs in oil palm plantations is 3 years, 5 years and in forest areas in terms of 2.83 mm, 2.46 mm and 0.52 mm.
3. The nutrients are lost in erosion and runoff from the oil palm plantation area of 3 years and 5 years is higher than in the forest area and in all the land cover most of the nutrients are lost along with the sediment, and only a small portion in the water surface flow.

4. The total N content in eroded sediments and surface runoff in oil palm plantations aged 3 years, 5 years and forests respectively are 12.91 kg ha^{-1}, 13.05 kg ha^{-1} and 1.94 kg ha^{-1}. The total P-content lost in erosion and runoff was 2.82 kg ha^{-1}, 1.62 kg ha^{-1} and 0.50 kg ha^{-1}, while the average K loss was 10.48 kg ha^{-1}, 15.18 kg ha^{-1} and 1.61 kg ha^{-1}.

Suggestion

Further research needs to be carried out by applying the treatment of soil and water conservation techniques in the area of oil palm plantations to reduce the impact of erosion and surface runoff, especially from oil palm plantations.

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REFERENCES

[1] Indonesian Ministry of Agriculture 2010 Area and production by category of producers: palm oil, Direktor at Jenderal Perkebunan. KementerianPertanian. Availableat: http://ditjenbun.deptan.go.id/index.php/direktori/3-isi/4-kelapa-sawit.html. (Consultedon April 13th, 2011)

[2] Susanti A and Burgers P P M 2012 Oil palm expansion in Riau province, Indonesia: serving people, planet, profit? Background Paper to the 2011/2012 European Report on Development: Confronting Scarcity: Managing Water, Energy and Land for Inclusive and Sustainable Growth. European Union, Brussels. Available at : http://erd-report.eu/erd/report_2011/documents/researchpapers_susanti-burgers.pdf (Consulted on January 27th, 2015)

[3] Wayan R S 2004 Contribution of Oil Palm Industry to Economic Growth and Poverty Alleviation in Indonesia. Jurnal Litbang Pertanian, 23(3): 107-114

[4] Environment Conservation Department. 2000. Environmental impact assessment (EIA) guidelines on oil palm plantation development. Environmental Conservation Department, Sabah, Malaysia. Available at: http://www.sabah.gov.my/jpas/programs/ecd-cab/technical/OP211100.pdf. (Consulted on Apr 13th, 2011)

[5] Goh K J, Härdter R. and Fairhurst T 2003 Fertilizing for maximum return. In: Fairhurst T, Hardter R (eds) Oil Palm: Management for Large and Sustainable Yie. Potash & Phosphate Institute/Potash & Phosphate Institute of Canada and International Potash Institute (PPI/PPIC and IPI, Singapore, pp 279–306.

[6] Sheil D, Casson A, Maijaard E, van Noordwijk M, Gaskell J, Sunderland G J, Wertz K, and Kanninen M 2009 The impacts and opportunities of oil palm in Southeast Asia. Center for International Forestry Research, Bogor.

[7] Breure K 2003 The search for yield in oil palm: Basic principles. In "Oil Palm: Management for Large and Sustainable Yields" (T. Fairhurst and R. Hardter, Eds.), pp. 59–98. Potash & Phosphate Institute/Potash Institute of Canada and International Potash Institute, Singapore.

[8] Campiglia E, Mancinelli R, Radicetti E, Marinari S 2010 Legume cover crops and mulches: effects on nitrate leaching and nitrogen input in a pepper crop (Capsicumannuum L.). Nutr. Cycl. Agroecosyst. 89:399-412.

[9] Goh K J and Chew P S 1995 Managing soils for plantation tree crops. 1. General soil management. In "Course on Soil Survey and Managing Tropical Soils" (S. Paramanathan, Ed.), pp. 228–245. MSSS and PASS, Kuala Lampur.

[10] Vitousek P M, Aber J D, Howarth R W, Likens G E, Matson P A, Schindler D W 1997. Technical report: Human alteration of the global nitrogen cycle: Sources and consequences. Ecological Applications, 7(3), 737–750.
[11] Nykvist, N. Grip, H., Liang Sim, B., Malmers, A. and Khiong Wong, F. 1994. Nutrient Losses in Forest Plantations in Sabah, Malaysia. *Ambio* Vol. 23, No. 3 : 210-215.
[12] Haridjaja O, Kukuh M, Sudarmo dan L M Rachman 1990 Hidrologi Pertanian. Jurusan Tanah, Fakultas Pertanian, Institut Pertanian Bogor. Bogor.
[13] Sukartaatmadja S 1998 Perlindungan Lereng dan Pengendalian Erosi Menggunakan Vegetasi Penutup. Jurusan Teknik Pertanian, Fakultas Teknologi Pertanian. IPB.
[14] Arsyad S 2006 Konservasi Tanah dan Air, Fakultas Pertanian IPB. IPB Press, Cetakan Ke Tiga. Gedung Lembaga Sumberdaya Informasi Lt. 1 Kampus Darmaga, Bogor.
[15] Rahim S E 2003 Pengendalian Erosi Tanah dalam Rangka Pelestarian Lingkungan Hidup. Edisi I. Bumi Aksara. Jakarta.
[16] Carlos O, Claudia A, Patricio R, Roberto G dan An Deschrijver 2007 Effects of Land Use Conversion from Native Forests to Exotic Plantations on Nitrogen and Phosphorus Retention in Catchments of Southern Chile. Water Air Soil Pollut (2007) 179:341–350.
[17] Comte I, Joann K W, Olivier G, Francois C, and Jean-P C 2012 Agricultural Practices in Oil Palm Plantations and Their Impact on Hydrological Changes, Nutrient Fluxes and Water Quality in Indonesia: A Review. In Donald L. Sparks, editor: Advances in Agronomy, Vol. 116 Burlington: Academic Press, 2012, pp. 71-124.
[18] Ariesca R 2004 Studi Tentang Terjadinya Erosi, Aliran Permukaan, dan Hilangnya Unsur Hara Dalam Aliran Permukaan Pada Lahan hutan Sekunder 1 Tahun Bekas Terbakar. *Skripsi*. Bogor: Depertemen Manajemen Hutan Fakultas Kehutanan Institut Pertanian Bogor.(Online).(http://repository.ipb.ac.id/ bitstream/handle/123456789/ 19012/ E04RAR.pdf? sequence=2, diakses 11 Oktober 2012).
[19] Murom B, Max A T, David R S, and Paul N N 2008 C Losses of nitrogen fertiliser under oil palm in Papua New Guinea: 1. Water balance, and nitrogen in soil solution and runoff. Aust.J. Soil Res.46 :332-339.
[20] Kee K K and Chew P S 1996 Nutrient losses through surface runoff and soil erosion—Implications for improved fertilizer efficiency in mature oil palms. In “Proceedings of the PORIM Internation Palm Oil Congress” (A. Ariffin, M. B. Wahid, N. Rajanaidu, D. Tayeb, K. Paranjothy, S. C. Cheah, K. C. Chang, and S. Ravigadevi, Eds.), pp. 153–169. Palm Oil Research Institute of Malaysia, Kuala Lampur.
[21] Syahrul K, Marife D C, Sri R U and Edzo V 2018 Soil Biochemical Properties and Nutrient Leaching from Smallholder Oil Palm Plantations, Sumatra-Indonesia. AGRIVITA J. of Agric.Sci. 40 : 257-266.